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WILDLIFE CONSERVATION IN CANADA

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The position occupied by the wildlife resource in Canada can be appreciated only in relation to the unique geographic situation prevailing. Canada has an area of about 3,850,000 square miles; it is larger than the United States of America, including Alaska, by about 300,000 square miles. The population is concentrated along the southern fringe and there are many large areas without any inhabitants. In the most densely populated province, Prince Edward Island, there is an average of 45 persons per square mile but this is also the smallest province, 2,184 square miles, and has little effect on the general population density. British Columbia, Alberta, Saskatchewan and Manitoba all average less than four persons per square mile and in the Northwest Territories density was only .013 per square mile in 1951. The total population of Canada in 1951 was composed of 13,582,574 whites, 105,874 Indians and 9,733 Eskimos.

Ninety per cent of Canada's area is in forest or wilderness land. Here the sparse population relies almost exclusively upon basic natural resources. There are 712,000 square miles of productive forest land upon which forestry outranks all other sources of wealth, but over the remaining three-fourths, wildlife is the only renewable natural resource upon which the human population can depend.

Furthermore the unique legislative position of wildlife on the North American continent, the high standard of living, and the very large areas of land under government ownership and free to public access, have given wildlife an exalted recreational value in the eyes of the urban and suburban populations. Any citizen can, for a modest sum, secure a license to hunt game and be assured of a place to hunt.

In Canada as in Britain the game alive is the property of the Crown (i.e. the state) but dead it may legally be claimed by the owner of the land upon which it falls. However, in point of fact, the owner or lessor of land upon which game is raised assumes no title to it and exercises control over its harvest only by virtue of the trespass law.

It will be perceived that this concept of state ownership of wildlife has some disadvantages. The most important of them is that it discourages private effort in game conservation. On the other hand it permits a unified effort over large areas and makes possible very wide public use of the resource.

Another important consideration is the ownership of game lands. Provincial or federal ownership of land not in use for agriculture is the rule. In British Columbia for instance 97 per cent of the forested land is owned by the province. On this the allocation of timber leases does not include rights to the game in the forest though it does grant the right

to control access under certain circumstances. In general, provincial governments do not lease shooting rights on public land. The only exception to this of which I am aware is in the Province of Quebec, where hunting clubs can lease hunting rights on certain tracts of government-owned land.

In any country the primitive position of wildlife is that of a basic resource for food and clothing. The advance of settlement through the pioneering phase to stable agriculture, urbanization, and industrialization brings accompanying changes in the concept of wildlife. Certain species become recognized as of continuing primary economic value, others become largely of sporting interest. Finally man comes to take an interest in the fauna for itself; he finds in living animals a source of interest that vitalizes his enjoyment of outdoor recreation.

In Canada all stages of this evolution are to be seen contemporaneously. In the northern areas game is still recognized as a native food supply. In most regions it can be taken throughout the year by surveyors and mining prospectors for their own use. Most Canadian big game hunters are still interested primarily in the meat of animals they shoot. In the National Parks, on the other hand, the increased opportunity for human contact with all wildlife is stimulating an understanding of its value as a unique feature of Canada. From coast to coast there is a rapidly widening interest in wildlife for itself.

One of the most notable trends in the wildlife picture has been the great increase since 1943 in hunting and fishing as a recreation. The situation in British Columbia is illustrative. Here the number of licensed hunters increased from 37,648 in 1943 to 85,313 in 1951.

TRAINING OF WILDLIFE CONSERVATION OFFICERS

Qualifications expected of non-technical conservation officers and game wardens are indicative of the stage Canada has reached in the evolution of wildlife conservation from a purely policing and administrative operation to a progressive management approach. In general the qualifications are still nebulous and, in most provinces, there is no examination for selection nor organized training period. Ideas are changing however, and Ontario in particular has a well organized school where conservation officers take a 33-week training course, one-third of which is devoted to game and fisheries biology and techniques. Saskatchewan also has an extended period of training for its conservation officers. There has been general endorsement of this trend by administrators of provincial departments. Certainly better opportunities for the field officers to increase their knowledge and skill would promote more rapid advance toward the ideals of wildlife conservation.

THE ADMINISTRATION OF CONSERVATION ACTIVITY

The greatly varied status of wildlife with respect to type of land occupied, and to its position in the economic and social organization of the people, has produced a diversity of interest in the resource and its conservation. This is both a strength and a weakness. No other resource has so great an appeal to the general public, and the many public, semipublic and private organizations with an interest in wildlife conservation are an expression of this fact.

The great popular interest, and the influence exerted by the public in shaping policy in Canada make imperative

an organized effort to explain research findings and consequent action to the public. Up to the present, information and techniques are ahead of application quite largely due to deficiencies in the educational or extension work of conservation departments. One of the most important tasks today is the strengthening of this effort.

In general, natural resources are administered by the provinces, not by the federal government. Thus the resident wildlife of each province is under provincial jurisdiction. It has been recognized, however, that migratory species and pelagic sea mammals along the coasts are under the jurisdiction of the federal government, as are the resources of land areas administered as national assets; i.e. the National Parks, Yukon Territory, and Northwest Territories.

The authority to administer the migratory bird regulations derives from Section 132 of the British North America Act which gives the federal government the powers necessary to carry out the terms of international treaties. Thus ratification of the Migratory Birds Treaty conferred upon the federal government all powers necessary to carry out its terms. Apart from this, ownership of the birds remains with the provinces.

ADMINISTRATIVE ORGANIZATION AT THE NATIONAL LEVEL

The Department of Northern Affairs and National Resources includes most of the federal government branches involved in wildlife conservation. It is organized as five branches: Administrative Services, National Parks and National Museum, Engineering and Water Resources, Northern Administration and Lands, and Forestry. Northern Administration and National Parks are the two branches directly concerned with wildlife. The latter comprises three divisions: National Parks and Historic Sites, National Museum, and Canadian Wildlife Service.

THE CANADIAN WILDLIFE SERVICE.—This service, so named in 1947, is a comparatively new department, still in a stage of development. The Service administers the Migratory Birds Convention Act under which most species of birds are protected throughout Canada; it maintains the central bird banding office; establishes and now administers 90 bird sanctuaries with a combined area of 1800 square miles. It carries on research upon migratory birds in all parts of the nation and upon all forms of wildlife in the National Parks and the two northern territories. It acts as a coordinating agency in the field of wildlife conservation supplying information and assistance to other government agencies. It holds annual conferences that bring together administrative officers of the provinces with those of the national government and promotes integration of effort.

THE NATIONAL PARKS BRANCH.—This bureau administers 28 National Parks in nine of the ten provinces and with a total area of 29,146 square miles. Its wildlife regulations are largely based upon studies made by the Wildlife Service but all enforcement and management is undertaken by parks officers.

THE NORTHERN ADMINISTRATION AND LANDS BRANCH.—The division administers wildlife conservation regulations in the Northwest Territories. It maintains a small staff of game wardens in the western Arctic but game law enforcement is undertaken largely by the Royal Canadian Mounted Police. Here too the Wildlife Service serves as the research and advisory body and has several of its biologists permanently stationed in the Northwest Territories.

THE DEPARTMENT OF CITIZENSHIP AND IMMIGRATION. — This department is charged with the welfare of native peoples in all parts of Canada. In the Northwest Territories and Yukon there is close co-operation between the administrative councils and the authorities of the Indian Affairs Branch of the Department. Here special wildlife regulations are in force with respect to Indians and very large preserves are kept exclusively for the use of the natives as hunting and trapping grounds. Wildlife plays so important a part in the well-being of the native peoples that the Indian Affairs Branch has an establishment to promote improvement of trapping conditions. The work of that establishment is especially directed toward beaver conservation and is discussed in more detail below.

THE DEPARTMENT OF FISHERIES AND FISHERIES RESEARCH BOARD.—These two bodies exercise administrative control over, and conduct research upon, marine mammals in Canadian waters.

CONSERVATION AT THE PROVINCIAL LEVEL

Each of the ten provinces regulates the use of its sport fisheries and resident wildlife. Provincial interest then is expressed in legislation for conservation of resident fish fauna, fur-bearing and game mammals, non-migratory game birds, and migratory birds not protected under the Migratory Birds Convention Act. It should be noted that the act dealing with sport fisheries is a federal act, but research and general administration is carried out by the provinces. Provincial authority extends also to measures for controlling predatory mammals and destructive birds.

It is general for the game and sport fish conservation to be under the immediate direction of one man as Commissioner or Director, and for that man to be a civil servant. Beyond this, however, there is little uniformity in the provincial departments in charge of the resource. It is not possible, nor indeed profitable, to discuss the machinery of conservation within each province. The more important details are summarized on Table 1 and will not be recapitulated. It will be seen that one group of provinces, including British Columbia, Manitoba, Quebec, and Newfoundland has its wildlife conservation distinctly apart from other resources. Another group has its wildlife organization partly separate, usually at the upper administrative and research levels, while some or all of the enforcement and management work is allocated to officials responsible for the same activities in other resources. Alberta, Saskatchewan and Ontario can be so classed but there are wide differences in the detail of organization between the three. Still other provinces give the wildlife resource little if any special attention beyond the enactment of regulations and the collection of revenue.

OTHER CONSERVATION AGENCIES

Provincial sportsmen's organizations in Canada are numerous and numerically strong although in any one province their membership seldom includes more than a fifth of the licensed hunters and fishermen. There is usually a close liaison between sportsmen's organizations and game authorities that permits the sportsmen some voice in the preparation of regulations. These groups play a valuable role in the democratic process of convincing legislators of the need for, and public interest in, improved wildlife conservation.

The Hudson's Bay Company pioneered the fur trade over most of Canada and has been engaged in the business

TABLE 1.—ORGANIZATIONAL SUMMARY OF PROVINCIAL WILDLIFE CONSERVATION SERVICES

Province	Provincial Department	Senior Admin. Officers	Enforcement Officers	Biological Staff		Mgt. Staff	Predator Control	Total Staff	Annual Budget approx.	Annual Revenue approx.
				Game	Fisheries	Hatcheries Game Farms Fur Mgt.				
British Columbia	Attorney General	2 Commissioners	60	4	6	11 Fish Hatch.	8	102	650,000	801,000
Alberta	Lands and Forests	1 Commissioner	34 assisted by 140 foresters	1	1	8	...	55	257,000	416,000
Saskatchewan	Natural Resources	1 Commissioner (Game only)	5 + many resources officers	3	2	3 Fur Mgt.	?	18+	139,000	.....
Manitoba	Mines & Natural Resources	1 Director	60±	2	1	11±	1	101	600,000	.....
Ontario	Lands and Forests	1 Chief	200±	32 ←——→ + Research Dept.		20 Fur Mgt.	...	300+	3,000,000	3,065,000
Quebec	Game and Fisheries	1 General Superintendent	200	2+2	10+10 technicians	...	...	505	2,340,000	1,160,000
New Brunswick	Dept. of Lands & Mines	Chief of Fish & Wildlife	No special game officers (forest officers)	No biological staff		...	...	6	250,000*	350,000
Newfoundland	Mines and Resources	1 Director	17+50 part time	1	...	...	...	23	154,000	107,000
Nova Scotia	Lands and Forests	Deputy Minister	No special game officers	1	...	...	...	95	180,000*	195,000
P. E. I.	Ind. & Natural Resources	Deputy Minister	No special game officers	...	...	...	...	...	.....	.....
								Total	7,570,000	

* estimated.
\+ atypical organization.

since 1670. In 1932 it began experiments in beaver conservation that it has now extended over areas totalling more than 335,000 square miles adjacent to James Bay.

The Wildlife Management Institute is supported primarily by contributions from manufacturers of sporting arms and ammunition in the United States, but extends its conservation work into Canada where it maintains the Northeastern Wildlife Research Station at Fredericton, N. B., in co-operation with Ducks Unlimited, the U. S. Fish and Wildlife Service and the University of New Brunswick. It also grants research scholarships to Canadian students in wildlife biology. Since 1953 it has received financial support in Canada from Canadian Industries Limited, Ammunition Division.

The North American Wildlife Foundation is financed originally by private enthusiasts in the United States, but now receives substantial support from Canadian sources. It maintains the Delta Waterfowl Research Station at Delta, Manitoba, a centre of waterfowl research in Canada.

Ducks Unlimited (Canada) is another American organization privately endowed by American waterfowl hunters and dedicated to activities designed to increase the continental stocks of geese and ducks. Its most spectacular work has been in water conservation and in development of new breeding grounds for waterfowl. Its staff in Canada consists almost entirely of Canadians.

WILDLIFE AS A NATIONAL RESOURCE

The position of wildlife among the natural resources of Canada is difficult to estimate because of the diverse nature of its impact upon different groups in the population.

In the vast wilderness and remote areas of the nation the game mammals in particular provide an indispensable source of food. This is true, not only of resident native peoples, but also for white inhabitants of areas remote from sources of other food supply and for surveyors, prospectors and other travellers in the wilderness. It can be truly stated that without wildlife the northern half of Canada would be virtually uninhabited. The establishment of native communities and of later white settlement in the far north was, and largely still is, limited to localities where year-round local food sources were available. To the Eskimo and to many Indian groups, big game provides such an essential source of food and clothing that failure of supply results in severe privation. There are abundant signs, however, of a changing status for the northland and within ten years the expanding interest in this vast area will have radically changed the picture.

Solman (1952) reports upon an enquiry into the utilization of wild meat in Canada. He estimates that the current utilization is about 48,400,000 pounds of game meat annually consisting of deer and other big game 38 million pounds, waterfowl 6 million pounds and upland game birds 3 million. Various attempts have been made to place a dollar value on game meat. A recent computation based upon average cost of harvest of venison places the value at $1.50 per pound, a cost not much in excess of that of specialty domestic meats, and less than the price of domestic meat after transport into remote areas. If we use this basis of calculation we can place the cash values represented by this meat contribution to the Canadian larder at $72,500,000. This in itself is no mean addition to the national food supply, particularly when it

is realized that it is a crop largely produced on land otherwise barren.

The fur industry represents another major source of direct economic return from wildlife. Across Canada about 47,000 men depend upon trapping for all or part of their income. Again the importance to the welfare of the community increases northward. In the sparsely settled half of Canada, areas north of profitable agriculture, fur and minerals are almost the only sources of revenue. Of these only the former is renewable and can be counted on as a permanent source of the income that has become inseparable from life even for the more isolated native. This aspect is discussed in more detail below.

By far the greatest impact of the resource is as a source of recreation to the population at large. As nearly as can be estimated from license sales, approximately 20 per cent of the male population of Canada over the age of 18 years hold hunting or fishing licenses and thus take a direct part in the wildlife harvest and gain recreation in its pursuit. A large and increasing number of women and children also share this enthusiasm for hunting and fishing. It is impossible to number the many thousands who find in living mammals and birds a source of enjoyment and a stimulus to observe, study and photograph.

Over and above these sources of direct economic gain there are many more sources of secondary economic value. The fur buyers, tanners, manufacturers of fur products, wholesalers and retailers of fur garments; the guides, outfitters and resort owners catering exclusively or in large part to the hunting and fishing public all derive their living indirectly from the wildlife. A further large group that benefits is the manufacturers of hunting and fishing equipment.

CONSERVATION OF MIGRATORY WATERFOWL

The conservation of migratory waterfowl in Canada absorbs an important part of the effort and money expended upon wildlife management. The basic management approach has been through the adjustment of the kill to conform as closely as possible to the allowable part of the estimated crop.

Water impoundment programs on the drought-subject nesting grounds of the Canadian prairie provinces have contributed to the increase in the continental waterfowl population within the past fifteen years. In this connection the activities of the Prairie Farms Rehabilitation Administration of the Canadian government have made important contributions through the many thousands of acres of new water bodies it has impounded. Similarly, Ducks Unlimited has accomplished much.

At present there is an increasingly serious problem of waterfowl damage to agricultural crops, mostly grain. At first the mallard was responsible almost alone, but more recently the pintail has developed the grain-eating habit as also have greater and lesser sandhill cranes. The development of more satisfactory techniques for the prevention or control of crop damage is now a pressing task. Until such are available, there can be little advantage to further increasing the number of ducks and geese, especially in the central plains area and southwestern part of the winter range.

A point of interest in comparison with European conditions is to be found in the list of species of migratory birds for which a shooting season is allowed. In many or all parts of Canada open seasons are provided on geese (except *Chen rossi*), ducks, snipe, woodcock, coot, pigeons and doves.

Restrictive legislation in Canada in 1954 provided a definite open season not to exceed 90 days; and set daily bag limits (daily limits ducks 10; snipe, and woodcock 8, geese 5). Other regulations confine shooting to the hours of daylight; prohibit use of automatic shotguns, rifles of any sort; ban guns over 10 gauge; prohibit all self propelled boats, live decoys, bait or lights in the pursuit of waterfowl.

The sale of migratory game birds is prohibited except under special circumstances.

THE FUR RESOURCE AND ITS MANAGEMENT

The important place occupied by the fur resource in Canada will be apparent from the data presented in Table 2. This is a summarized statement of the harvest of wild fur taken in the several provinces and territories during the season 1950–51. Also shown is the dollar value to the trapper of each species across Canada and of all species for each administrative region. Because the provinces differ so much in area the raw fur value per square mile of the provincial area has been calculated. Although this figure must be used with caution because of the many factors that may influence it, it is nevertheless a more useful figure than the gross fur take for the area. It will be seen that the harvest for 1950–51 was just under 7 million fur animals with a total primary value of almost 20 million dollars. The importance of this contribution to the national income assumes increased significance when it is realized that it is distributed in large part in the remote areas where agriculture is either impossible or marginal. Fur is the paramount crop over thousands of square miles of Canada.

The most important wild-caught fur animals are muskrat, beaver, mink, red squirrel and ermine in that order. The first four of these together comprised about two-thirds of the value of the raw fur crop in 1950–51. It must be borne in mind, however, that these statistics are altered annually by the vagaries of the fur trade. The figures given are for a period when long-haired furs were out of fashion. Had this not been true, coloured fox in particular would have assumed a higher place. The existing catch of this species does not reflect its abundance and availability, it is merely that current prices do not justify the effort of skinning foxes. Violent fluctuations in the numbers of white foxes in the wild move this species rapidly up and down the scale of economic importance. Despite these influences the present situation is probably close to the true one over a long period because of the relative stability of muskrat, beaver and mink among the raw fur items.

The gross yield of each province in numbers of pelts or in the value of these is of little significance unless it is adjusted to the great differences in area that exist between, for example, Northwest Territories with an area of more than 1,250,000 square miles, and Prince Edward Island with only 2,184 square miles. As a rough guide to the fur yield per square mile in the different parts of Canada, the provincial yield in dollars has been divided by the area.

Many factors are involved in this index. Obviously the potential productivity of a region depends upon its ecology. Thus, for instance, the vast tundra areas of the Arctic regions have a very low potential. Newfoundland proper, as an island well isolated from the continental mainland, has been poor in variety and consequently low in biomass. The largely mountainous and conifer clothed area of British Columbia

TABLE 2.—CANADIAN WILD FUR PRODUCTION 1950–51

	B.C.	Alta.	Sask.	Man.	Ont.	Que.	P.E.I.	N.B.	N.S.	Nfld.	Y.T.	N.W.T.	Total pelts	Dollar value
Badger	.....	134	499	69	.....	.....	....	.....	.....	.....	.....	.....	702	743
Bear	73	.....	11	37	.....	240	....	.....	.....	3	36	13	413	1317
Polar bear	.....	.....	.....	.....	.....	20	....	.....	.....	.....	.....	357	377	9525
Beaver	13819	12382	14078	18400	87608	25143	....	.....	114	475	2663	6610	181292	4273002
Coyote	.....	13666	15707	3266	.....	.....	....	.....	.....	.....	80	2	32721	142584
Ermine	36061	78641	69973	69556	49180	47673	162	2147	6922	6380	4668	12105	383468	812468
Fisher	911	.....	304	216	798	1413	....	.....	.....	.....	37	11	3690	91337
Blue fox	.....	9	.....	8	.....	181	....	.....	.....	.....	.....	377	575	7245
White fox	.....	37*	25*	279	240	12241	....	.....	.....	589	5	39739	53155	690162
Red fox	219	2033	2409	4060	12393	10252	582	746	1946	690	247	1617	37212	66192
Cross fox	178	890	754	1190	797	496	162	.....	47	280	155	618	5495	18626
Silver fox	57	114	60	255	115	106	26	.....	.....	137	9	78	977	7611
Lynx	1399	2020	1014	1089	462	811	....	.....	70	648	1030	1767	10310	116047
Marten	12039	847	215	30	1217	95	....	.....	.....	.....	2045	4542	21030	536773
Mink	18911	4059	12596	25212	37653	20290	129	1421	2121	1406	991	6966	131755	3999294
Muskrat	103724	433998	302177	679899	656388	180648	1127	.....	35169	28809	70786	494746	2987471	6686927
Otter	948	101	366	1594	6819	3221	1	79	251	927	66	121	14494	374817
Rabbit	.....	8001	32781	6940	.....	.....	....	101	300	.....	.....	.....	48123	22487
Racoon	510	.....	23	74	18518	2553	114	359	2194	.....	.....	.....	24345	60639
Skunk	4	124	299	608	13435	1743	32	26	118	.....	.....	.....	16389	12872
Squirrel	407953	1165209	370292	378114	.....	92519	890	11497	290228	12190	145355	73463	2947710	1946760
Wild cat	.....	.....	3	.....	.....	61	....	226	359	.....	.....	.....	649	888
Wolf	.....	119	101	386	.....	44	....	.....	.....	.....	99	399	1148	7342
Wolverine	329	32	9	16	2	2	....	.....	.....	.....	344	48	780	18851
Total pelts	597133	1722416	823716	1191298	885625	399750	3225	16602	339857	52634	228616	643579	6907871	19950383
Total value (dollars)	1589233	2530978	1985287	3393413	5213602	2349667	6842	37344	285269	158450	361969	2038339	.....	.....
Sq. mile value (dollars)	4.3	9.9	7.9	13.7	12.6	3.9	3.1	1.3	13.5	2.4	1.7	1.6	.....	5.2
Human density per sq. mile	3.2	3.8	3.5	3.5	12.7	7.7	45.0	18.8	31.0	.....	.04	.013	.....	3.7

Table excludes pelts submitted for bounty and not entered into the fur trade.
* Probably not trapped in the province.

offers a reduced area of habitat suitable for the highly productive staple fur species.

Another influential factor is the state of the fur market with respect to the species of fur animals abundant in any region. Density of human population below a certain level also influences intensity of trapping. Here again Northwest Territories will be affected. Its small population and vast area of reserves set aside for the exclusive use of the natives, much of it not used at all, serve to lower the yield.

Over and above these influences, the general state of fur animal conservation in each province probably plays the deciding role. This is not to say that an unproductive province is now either deficient or depressive in this respect as it takes several years for a constructive program to bear fruit. The yield does, however, reflect past deficiencies rather clearly. It is difficult, for example, to explain the differences in yield among Quebec, Prince Edward Island, New Brunswick, and Nova Scotia without reference to past and possibly present deficiencies in fur animal conservation. Local closed seasons, as for example that on muskrat in New Brunswick can, of course, radically alter the yield in any one year and bias comparisons. It is also possible that differential fur prices between Nova Scotia and New Brunswick resulted in the sale of some New Brunswick pelts in Nova Scotia where fur prices were slightly higher.

The very high yields in Ontario and Manitoba reflect the outstanding success these provinces have had with their well planned and financed management programs specifically directed toward beaver, muskrat, and mink. The high yield in Nova Scotia is in a different category as it rests largely on an intensively harvested squirrel population. Nova Scotia produced almost 15 squirrel pelts per square mile against the next highest crop of about five per square mile. It also had a relatively high yield of mink, muskrat and weasel compared with adjacent areas.

A more critical examination of fur animal stocks in the different ecological regions of Canada under varying conditions of management and neglect would be most valuable.

FUR ANIMAL CONSERVATION METHODS.

The mechanisms for improving the yield of the fur resource fall into four main categories:

1. Control of the harvest so as to take the full surplus but no more.
2. Measures designed to improve the habitat and increase its carrying capacity.
3. Establishment of species extinct or rare in habitat otherwise favourable.
4. Measures designed to improve the quality of the crop.

The basic approach to fur animal management has been the same in Canada as elsewhere. Special licenses have been required of trappers; the open seasons have been set so as to assure the taking of animals when fur is in prime condition; harvesting practices regarded as particularly destructive, unselective, or subject to abuse have been forbidden. In general, however, any attempt to relate the take to the surplus has been left to the initiative of the trapper without guidance.

The first major advance in fur animal management was the inauguration of a system of registered trap lines or trapping areas developed by the province of British Columbia between 1927 and 1932. This system recognizes the trapping rights of an individual on a certain area, outlines the boundaries of the area, and protects him from encroachment or

displacement so long as he operates according to the principles of conservation. A review of the results of 20 years' experience of this system has revealed it to be an important forward step that has stabilized the industry in the province and permitted increases in a few species. The plan has been widely adopted throughout Canada and with slight modifications is in force in at least part of every province except Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland. By its nature the plan is applicable only where large areas are still the property of the Crown.

Manitoba, in 1936, initiated the first large scale attempt to improve the fur crop by developing the habitat. Because the projected area was partly Indian trapping ground that had deteriorated seriously, the federal Indian Affairs Branch co-operated with the province in financing the experiment. The idea was to control the water levels in part of the Saskatchewan River delta and thus to improve it as muskrat habitat.

In 1936 about $107,000 was spent in development work on the 140,000-acre Summerberry Project. A closed season was maintained for the four subsequent years and the 5,000-animal seed stock increased to an estimated 200,000 muskrats. During the next four years over half a million pelts were taken and sold for more than one million dollars. The provincial government's share of $220,000 more than repaid all expenditures incurred in the development.

With the experience gained here, Manitoba and later Saskatchewan proceeded to develop their large management programs for muskrat and beaver. From this beginning also the interest of the federal government in progressive fur animal management as a means of bettering the lot of the native Indians and Eskimos expanded steadily. It now has co-operative agreements with Ontario, Quebec, Manitoba and Saskatchewan (Conn, 1951).

Experiments with beaver management were begun by the Hudson's Bay Company when they established Rupert's House Reserve in 1932. This had an area of 7200 square miles and contained only some 25 beaver. Trapping was begun in 1940 after eight years of careful protection. Since then 23,000 pelts have been taken on the reserve with the maintenance of a mean lodge count of 2400, or one for each three square miles. The permitted take has been one animal per lodge except during disease epidemics when the quota has sometimes been as much as doubled. About 125 Indians hunt this area.

The largest of the Hudson's Bay Company beaver reserves is 17,000-square-mile Fort George Reserve. Starting with almost nothing in 1943 the lodge count now stands at about one per ten square miles and 1700 pelts were taken in 1952 by the 100 Indians that hunt it. Two other reserves on islands in James Bay total over 11,000 square miles and are used primarily as a source of planting stock.

The success of these projects has been matched by those of the Indian Affairs authorities in their many beaver management areas operated in conjunction with the provincial game authorities.

The beaver program has consisted of detailed investigation of the population, water level control, forest fire control, transplanting and re-stocking, protection, developing harvesting methods designed to distribute the kill where it was desired, and an active, on-the-spot educational program. The trappers themselves have been incorporated into the organization, and, under the guidance of fur management officers, take an active part in the conservation work.

Such close contact has also made possible the dissemination of the most advanced information on methods of handling the pelts. This alone has served to increase the value of the pelts by as much as 20 per cent.

Currently the major problem is the control of periodic epizootics that create havoc in areas densely populated by beaver.

Muskrats have proven more difficult to manage on a sustained basis than beaver. They increase very rapidly in suitable new habitat but have been more subject to epidemic disease. A further difficulty has arisen in a deterioration of new marshes a few years after their establishment. Much has yet to be learned about the management of this species in a northern region.

A recent development has arisen out of the discovery that a large part of the potential crop on vulnerable or heavily stocked areas perishes before the usual trapping season. Progressive management now makes provision for taking this depreciating surplus in the early winter even though the fur quality is not at its best.

Saskatchewan has concentrated on developing a co-operative approach to fur animal management. In addition to registered trap lines of the conventional sort, it has also set up three large Fur Conservation Blocks, encompassing most of the province north of the 53rd parallel of latitude. These blocks are subdivided into fur conservation areas on a community basis, using the long-established trapping areas of the residents of each community. They are in essence community trapping areas. Within them individuals, families, or groups of trappers register and work their own lines or areas upon which they may take for their own use all fur bearers but beaver and muskrat. These two species are harvested as a community asset on a basis of one beaver (rarely more) for every occupied lodge and 60 per cent of the estimated muskrat population. No permits for beaver are issued until there are at least five lodges for each trapper. In ten years, more than 2500 beaver have been transplanted into these areas.

All beaver and muskrat pelts must be delivered to the game department which sells them through the Saskatchewan Fur Marketing Service. Twenty per cent of the proceeds are paid into the treasury and the rest is distributed to the trapper catching the animals or, on a pro rata basis, to all trappers registered on the Conservation Area. If no public funds have been expended in development work on the area concerned, the amount payable to the province is 10 per cent instead of 20 per cent. An important part of the scheme is that in each Conservation Area the trappers appoint a Fur Conservation Council of five of their number to act with the government authorities. These men are appointed as deputy game wardens.

Upon areas further south in the province, where muskrats are the main fur crop, a number of Muskrat Development Projects have been set up. Marsh management consists of water control, organized trapping based upon an allocated take of 60 per cent of the autumn population, uniform preparation of pelts, and co-operative marketing. In some instances the proceeds are distributed to the trappers in monthly payments rather than in one sum.

The Saskatchewan Fur Marketing Service is another new experiment in fur resource management. Established as a Crown corporation in 1944, it aimed to provide the trappers with auction facilities, and to improve the quality of the product by educating the trappers in improved techniques of handling. It

has proven itself a valuable part of the complex system of fur management developed in the province.

Ontario now has the largest and most intensive fur animal conservation program in Canada. A staff of 33 men and an annual budget of $242,000 are devoted to this work. So far, beaver has been the main subject of attention but the increase in mink has been most spectacular. Fisher, marten and lynx have shown little sign of improved population under the various management schemes so far tried in Canada. They are the subject of special study in Ontario in the expectation that suitable techniques for these species can be devised. Two experimental trap lines are yielding much valuable information on several aspects of fur animal management.

PREDATORY ANIMAL CONTROL

Several million dollars have been spent on efforts to reduce the numbers of certain predatory mammals and raptorial birds. The major control effort has been directed against wolves, coyotes, mountain lions, crows, magpies and goshawks but many other species have received sporadic local attention. For the most part these attempts have not been designed for nor directed toward any special game management objective. The primary motive has been to control damage to domestic livestock and, secondarily, to extend the presumed benefits to certain game species. The classical bounty system has been popular in Canada, where it has proved as ineffectual as it has elsewhere.

Even though this is generally admitted, almost all provinces still persist in its use, largely in response to public demand. In 1951 bounties paid totalled about $180,000, of which British Columbia with $51,133 paid the largest amount. Since then however, British Columbia, Alberta and Saskatchewan have discontinued the bounty on coyotes although it is still maintained on timber wolves.

The experiments of the U. S. Fish and Wildlife Service have produced several new and effective techniques for controlling nuisance animals that are now widely used in Canada. British Columbia has established a control division using the latest techniques for destroying the larger predatory mammals, and is attempting to apply control toward specific ends. Similar programs differing in detail are in force in Alberta, Saskatchewan, Manitoba, and Ontario. The new programs have proven particularly successful. For example, in Saskatchewan formerly as much as $100,000 per annum were spent on bounties for coyotes there without lessening the numbers. In 1951, $50,000 spent on organized control produced notable decrease. In several provinces the holders of registered trap lines are expected to assist by controlling predatory species on their areas.

GALLINACEOUS GAME BIRDS

The native species of gallinaceous birds have been the subject of several research studies but no special programs of management have been instituted. All species are slightly or violently cyclic in at least part of their range and the standard practice is to impose a closed season when numbers are low. Recently Alberta has pioneered in an attempt to harvest a much larger proportion of the population during years of great abundance. The objective is to remove birds that will otherwise overcrowd the suitable range and become subject to displacement hazards; to take advantage of the known phenomenon of inverse rates of gain; and, if possible, to reduce

the severity of the decline by reducing the density that precedes it. The approach offers encouraging possibilities but is still unproved. One difficulty is that in Canada hunting intensity is seldom equal to the task of removing enough birds during peak years.

Several races of pheasant (*Phasianus torquatus* and *P. colchicus*), the European gray partridge (*Perdix perdix*) and recently the chukar partridge (*Alectoris graeca*) have been introduced into various parts of Canada. The first two maintain self-sustaining populations. Pheasants in particular are still subsidized by the annual liberation of some 88,000 pen-reared birds, but it has been shown that these play a quite insignificant part in the annual kill. Research has led to the adoption, by at least two provinces, of liberation techniques that give some improvement in survival to the first hunting season, but even these fall far short of making the program an economically sound one once the establishment phase of a new population is over. In general the provinces do not own or operate their own game farms. They either buy birds from private farms, subsidize the sportsmen's organization to raise birds, or, as in Ontario, own the game farms but contract for their operation.

Manitoba is experimenting with habitat improvement in an effort to improve the productivity of its pheasant range.

BIG GAME

Intensive management of big game stocks has not been considered necessary in Canada. Until recently, given the protection of bag limits, closed seasons, predator control where necessary, big game stocks were maintaining themselves satisfactorily. In fact the past twenty years have seen some notable increases of species previously reduced to a very low ebb. However, the changing conditions introduced by an expanding agriculture, increased commercial exploitation of the remote areas, and a steadily increasing demand for the recreational use of wildlife have made a more constructive, informed and precise management imperative. Some local populations are currently at a low ebb, as, for instance, the mountain caribou in British Columbia; others are so abundant as to exceed the capacity of their winter ranges.

The increased interest in the welfare of the big game species has manifested itself in a series of fact-finding studies. The Canadian Wildlife Service has been concentrating on the barren-ground caribou and muskox; and intensive studies of the moose have been completed in Ontario and British Columbia and are in progress in Manitoba, Quebec, Nova Scotia and Newfoundland. Some of the findings have already been translated into improved regulations.

In the matter of game stocks moose in western Canada have made spectacular increases since the early 1930's; the smaller deer (*Odocoileus*) have remained at a high level with some climatically induced fluctuations. Wapiti (*Cervus canadensis*) have increased steadily since 1927; muskoxen have shown encouraging improvement; bighorn sheep (*Ovis canadensis*) suffered a serious epizootic about 1948 and is recovering slowly; thinhorn sheep (*Ovis dalli*) and the mountain goat (*Oreamnos americanus*) have remained at about the same level. Some of the peripheral herds of barren-ground caribou (*Rangifer arcticus arcticus*) have apparently been seriously reduced while the mountain caribou (*Rangifer arcticus montanus* and *R. a. osborni*) have been at a low ebb during the last ten years but are increasing again. Woodland caribou (*Rangifer cari-*

bou) are dangerously reduced except on Newfoundland. The status of *Rangifer pearyi* is enigmatic, *R. dawsoni* is apparently extinct.

Moose have been introduced to Newfoundland; white-tailed deer to Nova Scotia and to Anticosti Island, and Columbian black-tail deer to Queen Charlotte Islands, all with outstanding success.

The most serious dangers to big game now are loss of key winter ranges to agriculture, local overexploitation of particularly vulnerable populations, and failure to adequately crop many capacity stocks. The latter situation occurs here and there almost from coast to coast in the deer (*Odocoileus*), and in British Columbia the moose is involved. This persistent over-crowding of winter ranges is leading inexorably to smaller, less productive stocks on browsed-out ranges.

In British Columbia experiments are in progress with the use of fire in unproductive forests to improve grazing and browsing conditions. However it is doubtful if the planned use of fire for this purpose will be feasible except to a very limited degree. The failure of a general appreciation of the carrying capacities of wild ranges and the consequent necessity for limiting the size of wintering herds remains a major stumbling block in the path of improved big game management in many parts of the country.

Current management measures consist of attempts to regulate the kill in conformity with the stock, to encourage proper distribution of the kill, to give protection from predators or other unusually destructive circumstances where necessary, to safeguard critically important winter ranges from alienation or from destructive overuse by domestic livestock, and to explore methods of range rehabilitation.

Over most of Canada the harvest of big game is restricted to males except in mountain goat and barren-ground caribou. Several provinces have recently begun taking females from fully stocked ranges but it has proven as difficult here as elsewhere to convince the sportsmen that there can be such a condition as over-population of game.

In most provinces non-resident sportsmen pay a much higher license fee than residents and, while hunting big game, must be accompanied by a registered guide of the province concerned.

British Columbia is experimenting with the allocation of guiding areas to these men somewhat after the registered trapline pattern. A complication occurs because resident sportsmen have uncontrolled access to all areas.

MARINE MAMMALS

Small scale whaling operations take place on both coasts of Canada. The 1951 catch off the coast of British Columbia amounted to 437 whales—finbacks 216, sperms 153, humpbacks 51, blues 9, sei 8. On the Labrador coast the catch was 585 whales of the large species and in addition 55 mink whales and 3102 blackfish (*Globicephala*).

The products from these mammals were 4,408,016 lbs. of ordinary oil, 1,989,617 lbs. of sperm oil, 4,098,780 lbs. of guano, 2,860,000 lbs. of whale solubles, 1945 tons of whale meat, and 36 tons of soluble meal.

The 1951 catch of seals totalled 256,728; most of these were harp seals taken on the Newfoundland coast. The take of Alaska fur seals is shared with Britain and the United States on a basis established by treaty. There is a bounty on harbor seals in British Columbia and

sporadic attempts are made to reduce the population of sea lions there.

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SUMMARY

In Canada wildlife is regarded as common property and title to it does not go with other surface rights on the land. Under this basic circumstance and with the largest part of the wild land in public ownership the wildlife contributes importantly to the national economy and social organization.

The annual wild meat consumption is about 48 million pounds, and the raw fur harvest of about 7 million pelts in 1951 sold for about $20,000,000. A very large proportion of the population make use of wildlife as a source of outdoor recreation.

In general wildlife stocks are in good condition and few species are declining through over-killing. At the same time only a few species are realizing their full potential. Canada has pioneered important advances in fur animal conservation especially with beaver and muskrat. The control of predatory mammals and the management of migratory waterfowl have also benefited by the recent change to positive rather than negative measures in conservation. On the other hand the conservation of big game mammals and gallinaceous birds has lagged far behind.

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REPRODUCTION OF THE BRUSH RABBIT IN CALIFORNIA

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The brush rabbit (*Sylvilagus bachmani*) in California is almost totally neglected by sportsmen. Because the human population in the vicinity of San Francisco Bay is increasing, more interest will undoubtedly center on the brush rabbit in the future. In anticipation of such increased interest this study was undertaken to serve as a basis for intelligent management of the brush rabbit as well as to contribute some fundamental knowledge of this common but poorly known species.

Information on brush rabbit reproduction such as number of young per litter, breeding season and post-natal sex ratios has been published by other authors. In this paper the breeding season as shown by the gross relationships of the testes and accessory reproductive glands in the males is compared to the breeding season of the females. The gestation period is estimated, and information was obtained that bears on such important aspects of reproduction as prenatal mortality, ovum wastage, resorption rate, and comparison of ovulation rates of left versus right ovaries.

Methods

All data were obtained from wild caught animals except for one litter of five born in captivity. A few rabbits were held in captivity for various lengths of time. Rabbits were collected at the following locations in central western California: Lake County, 1 individual; Alameda County, 13; Contra Costa County, 7; Marin County, 19; and Napa County, 41, all of which were taken on two islands in the lower Napa River.

It was originally assumed that the brush rabbit could be live-trapped with reasonable success, and since this would supply animals that might be bred in captivity, it was adopted. Eventually box trapping was discontinued, and steel trapping, snaring, and hunting with a beagle were tried. The only reasonably successful methods were snaring and hunting.

Most of the animals were weighed, measured and dissected soon after collection. Vaginal smears were made of all females, and externally observable condition of the mammary glands was recorded. The positions of the testes were recorded, and smears were made from the middle of the testis and tail of the epididymis. After removal, reproductive tracts of both sexes were fixed in Bouin's fluid, and the mammary tissue of the females was measured.

Each testis and epididymis was weighed and measured after fixation. After all measurements had been made, a thin transverse wedge was cut from the middle of the testis on the ventral side. This wedge was than placed in dioxan. The seminal vesicles, vesicular and prostate glands were weighed together after trimming off the bladder, most of the vas deferens, fat, and the entire urogenital tract caudal to the prostate gland. The seminal vesicle and vesicular glands were measured together.

After marking the right ovary with

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acid fuchsin, both were placed in dioxan. The absence, or presence and position of uterine swellings was noted. Large embryos were removed, but very small embryos were not. Evidence of resorption was recorded. Records were made of color of embryos, presence or absence of body hair, vibrissa length, hind foot length, distance from nose to occiput and from occiput to base of tail, total length or crown rump length, and weight. In large fetuses, the measurements of occiput to base of tail, and total length were taken around the head and back contours since this seemed least subject to error. Embryos that were old enough were sexed internally (Brambell, 1944).

Infiltration was by the dioxan-paraffin method, and the sections (10–13μ) were stained with Harris' hematoxylin and eosin bluish. Ovarian serial sections of four individuals showed that saving every twentieth section at 10 microns would give satisfactory coverage.

Three to five sections were mounted from one testis of each male. These also were stained with hematoxylin. All smears that did not show spermatozoa were stained with Giemsa and searched again.

RESULTS

Male brush rabbits seem capable of breeding from October or more likely November, through June or possibly July.

The period of greatest reproductive activity is roughly from January to April and perhaps May inclusive. Figs. 1 and 2 show a definite peak at this period.

Testis sections of a male that was captured September 13 and died October 26, 1950, showed spermatogenesis starting, while no spermatozoa were found in the smears. Four males that died in December showed spermatozoa in their smears as well as in the testis sections. In all of these, as well as the October 26th male, the testes had descended, while two mid-September adults had abdominal testes. If part of one testis was scrotal, they were recorded as scrotal testes. Shock apparently causes partial withdrawal in practically all cases. The date when reproductive activity begins is well established by the foregoing and is confirmed by Figs. 1 and 2, which show that in the testes and accessory reproductive organs there is a decided increase in size from October to December.

The determination of June or possibly July as the end of the reproductive season for the males is based on the following evidence: One male on the twenty-second and another on the twenty-fifth of June had internal testes. The latter had an epididymal smear showing many spermatozoa, while relatively few appeared in the testis smear and in the testis sections. Another male that died in a trap on June 5, 1951, had scrotal testes. A low in June occurred for all measurements except the prostate width. It must be borne in mind, however, that the June point on the graphs is based on only one animal.

Males probably are not fertiie from July through October. This coincides with the driest period of the year in central western California, and lack of some nutritional factor or factors in the dry summer forage may cause this seasonal infertility. Day length might be a causative agent, but brush rabbits come into breeding condition during a period of decreasing day length, and go out of condition on a nearly maximum day length. It is possible, of course, that decreasing day length stimulates *S. bachmani* to breed in spite of the fact

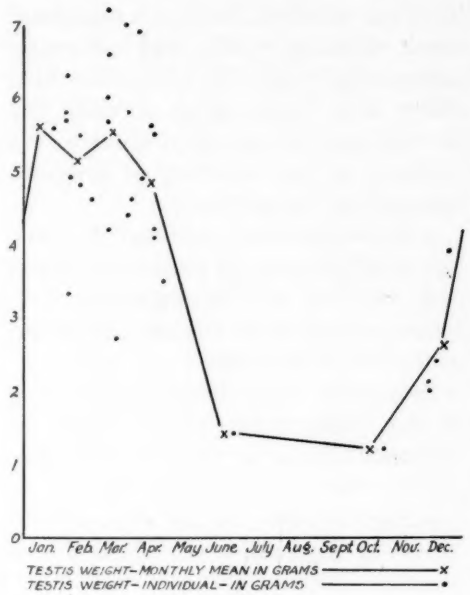

FIG. 1

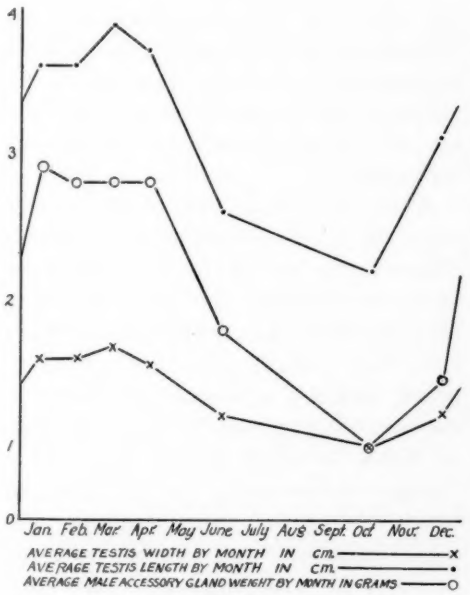
4
3
2
1
0
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
AVERAGE TESTIS WIDTH BY MONTH IN cm.
AVERAGE TESTIS LENGTH BY MONTH IN cm.
AVERAGE MALE ACCESSORY GLAND WEIGHT BY MONTH IN GRAMS

FIG. 2

that increasing day length causes increased reproductive activity in *S. floridanus* (Bissonnette and Csech, 1939).

Pregnant females may be encountered from the first week of December until about the end of June in the vicinity of San Francisco Bay. A female collected January 4, 1951, was suckling young and her uterus was still stretched. If the gestation period is about 27 days she must have conceived in the first week of December 1950. Two females captured the 19th and 27th of June did not give birth subsequently. It is possible that young were resorbed. May 27, 1951, was the last date on which a pregnant female was collected, and her four embryos included one definitely, and one possibly resorbing. If these embryos had gone to term, they would have been born in mid-June. A young female caught July 30, 1951, was estimated to be about one month old, so she was born about the end of June.

Peak of reproduction in the female lasts from January through May, while the period of reproductive inactivity is from July through November. Suckling females probably will be found through the first and possibly second or third week of July since they suckle the young for two to three weeks after birth. This was observed in the litter born in captivity and the same approximate duration of suckling was observed by Orr (1940).

Males are probably capable of breeding in November and the earliest females not until December. The onset of the season when conception can take place is therefore determined by the females. Peak of reproduction, January through May, coincides in the two sexes.

Gerstell (1937) says that the cottontail has a gestation period of twenty-five to thirty-two days and a mean of thirty days. Dice (1929) states that the Oklahoma cottontail has a probable gestation period of twenty-eight days or less, and Schwartz (1942) gives twenty-eight to thirty for the Missouri cotton-

tail. The eastern cottontail has been observed to have a gestation period lasting 26.5 days (Hendrickson, 1943). By using this information and the following evidence it should be possible to arrive at a likely figure for the duration of pregnancy in the brush rabbit.

One pair of animals bred in captivity, but produced no young. All other attempts to breed brush rabbits in captivity failed. A female collected March 21, 1951, was put with a male on March 22, but did not breed. Sometime between 5:00 p.m., April 13, and 9:00 a.m. April 16 she gave birth to five young. When found on the morning of the 16th, one was dead. All of the young were dry as was the umbilicus of each. Since the dead one was roughly of intermediate weight in the litter, was not noticeably decomposed, was dry, still showed rigor mortis, and had milk in its stomach; and since no afterbirth was present, it seems logical to place the birth date at approximately midnight, the evening of April 14–15. Since this female must have bred before she was captured, the minimum gestation period would be twenty-six days, plus or minus thirty-two hours. It seems reasonable to give a tentative figure of twenty-seven, plus or minus about three days, for the gestation period in *Sylvilagus bachmani*.

Four females were found to have corpora lutea and no visible swellings in the uterus. One of these females had practically no mammary tissue and did not give milk, so she ovulated while nonpregnant and not lactating. Another female had an extensive amount of mammary tissue, gave milk, had a stretched uterus, and had patches of plucked hair. She therefore ovulated while lactating, possibly in post-partum heat. The remaining two females had a little hair plucked, had much mammary tissue which gave milk, and had nearly normal-sized uteri. They therefore bred either while lactating or possibly just at the end of pseudopregnancy. No evidence of the breeding of pregnant females was encountered.

A female collected February 23, 1951, had small nipples, no mammary tissue, and was the only nonpregnant adult female encountered during the height of the breeding season.

Interstitial tissue makes up the bulk of the brush rabbit ovary. Large unruptured follicles are frequent and when atretic, form corpora lutea atretica as described by Allen, Brambell, and Mills (1947) in *Oryctolagus*. The corpora lutea resemble those of the domestic rabbit. Corpora lutea of the current pregnancy are readily distinguishable; however, a few days post partum it becomes very difficult to tell old corpora lutea from corpora lutea atretica. As a result, no attempt will be made to estimate the size of litters previous to the current pregnancy.

Allen, Brambell, and Mills (1947) state that in *Oryctolagus cuniculus* "there is . . . no possibility of omitting to count swellings that contain living embryos after the seventh day." Since the brush rabbit gestation period is poorly defined, it seems reasonable to use this same figure. This has been done in Table 1 which shows the weekly changes in embryonic development of brush rabbits. In order to prepare this table, embryos from females collected in the wild were compared with each other and with known stages of *Oryctolagus cuniculus* embryos as described by Minot and Taylor (1905). From this table, the age of almost any *S. bachmani* embryo probably can be determined to within about three days. Use of Table 1 helped to establish the last likely date

TABLE 1.—AGING EMBRYOS OF BRUSH RABBITS

Age	Body Hair Length	Vibrissa Length	Color	Ear From Notch Length	Hind Foot Length	Tip Nose to Occiput	Occiput to Base of Tail	Total Length or Crown Rump	Weight	Remarks
End of first, beginning of second week	.....	.....	Pale	.....	.....	.....	.....	C.R. 3 mm.	.....	.....
End of second, beginning of third week	.....	.....	Pale	A pad over external auditory opening <1 mm.	3–5 mm.	8–11 mm.	14–20 mm.	C.R. 15–25 mm.	0.4–2.0 gms.	Toes separate
End of third, beginning of fourth week	.....	0–3 mm.	Litter 64 pale except for top of head. Litter 91, pale eyelids, ears, muzzle tip, lower cheeks, tips of toes, ventral side just back of fore limbs, streak down center of back. Balance gray.	5–7 mm.	10–13 mm.	19–23 mm.	44–60 mm.	T.L. 77–94 mm.	7.6–13.0 gms.	By now can be sexed accurately
Just prior to birth	<3 mm.	6–8 mm.	Spot front of eyes, inside and outside of ears, nostril area, chin, throat, abdomen, toes, back of neck, streak down center back, pale. Balance gray.	10–11 mm.	18–19 mm.	26–29 mm.	87–95 mm.	T.L. 120–135 mm.	24.3–30.2 gms.	.....

for encountering pregnant females and a few other deductions contained in this paper.

Comparison of nearly full-term embryos with the young born in captivity and with the litters described in the literature makes it clear that young brush rabbits are born haired, and that they probably suffer a post partum weight loss.

With a gestation period of about four weeks and a peak period of reproduction lasting from January through May, a female brush rabbit could easily have four litters per year. Three litters is probably a reasonable figure if the female lives through the whole breeding season. In this area, probably no young breed in the same season in which they are born, whereas practically all breed during the reproductive season following their birth.

Based on 14 females that contained uterine swellings, the average litter size is four and the range is from three to six. By including two litters noted by Grinnell, Dixon, and Linsdale (1930), and ten litters noted on specimen labels in the Museum of Vertebrate Zoology collection at Berkeley, one gets a total of 26 litters. In these the mean in 3.69 and the range two to six. This includes some areas and subspecies different from those of my collections. Orr (1940), gives a range of two to five and a mean of 3.5 for 11 pregnant females from central and northern California. This probably is based on some of the Museum of Vertebrate Zoology data included above.

By checking current corpora lutea against number and position of embryos old enough to cause uterine swelling, it was found that two ova were wasted. This is based upon 53 of the total (56) embryos found. Twenty-four of the 53 embryos were found in the right, and twenty-nine in the left uterine horns, while 25 recent corpora were found in the right and 30 in the left ovary. A count of recent corpora lutea in all females shows 33 in the right and 42 in the left ovary. No cases were encountered where ova crossed to the opposite uterine horn.

Of the 14 embryo sets observed, a total of 56 embryos, three sets had one or more embryos definitely being resorbed. Five embryos were being resorbed and three others probably were. The data are insufficient to warrant using the method of Allen, Brambell, and Mills (1947) for calculating resorption rate in the wild European rabbit. It can be said, however, that the observed resorption rate is at least 12.5 per cent, and including the doubtful embryos gives a resorption rate of at least 17.9 per cent.

The fetal sex ratio is 13 males to 14 females, for all practical purposes a 1 : 1 ratio. These were sexed internally by dissection as described by Brambell (1944). Data on 82 postnatal specimens show a ratio of 128♂♂ : : 100♀♀. Brush rabbits in the Museum of Vertebrate Zoology at Berkeley total 160 males and 198 females, a ratio of 80.8♂♂ : : 100♀♀.

DISCUSSION

Brambell (1944) found that wild females of *Oryctolagus cuniculus* copulated both while pregnant and when not in estrus, as well as during their estrous periods. No evidence was found to indicate that female brush rabbits copulated at times other than during estrus. Breeding of non-estrous brush rabbits in the summer is unlikely since both sexes seem to go out of breeding condition at approximately the same time. Breeding of non-estrous females would be possible in the fall, however,

since males apparently come into breeding condition earlier than females.

By a refined method of calculation, Allen, *et. al.* (1947) have shown *Oryctolagus cuniculus* to have an estimated prenatal mortality of about 60 per cent, while computed in the usual way their data show a resorption rate of only 16 per cent (Brambell, *circa* 1948). The brush rabbits had an observed resorption rate similar to the smaller figure given above for *O. cuniculus*, and both figures were obtained in the same way. It is possible, therefore, that the actual resorption rate in *S. bachmani* is much higher than the 12.5 to 17.9 per cent given above. In fact it may be as high as that found in *O. cuniculus* by Allen, *et al.* (1947).

Domestic females of *O. cuniculus* are only partly successful in maintaining pregnancy while lactating. If the number of suckling young is three or less, pregnancy is usually maintained, but not always. Wild females of *O. cuniculus* successfully carry their litters while lactating, and these litters suffer only an average embryo loss. Females of *S. bachmani* also carry litters during lactation, but the resorption rate in these litters is not known and might prove higher than that in pregnant nonlactating females.

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SUMMARY

Male brush rabbits capable of breeding may be encountered from November to June, and females from December to June inclusive. The peak of reproductive activity lasts from January through May in both sexes, the period of infertility coinciding with the dry season in central western California.

The gestation period is deduced to to be about 27 ± 3 days, and females probably breed soon after giving birth. As a result, an adult female that lives through the entire breeding season could raise three or even four litters with a maximum of six litters possible. The young of these litters in the vicinity of San Francisco Bay probably do not reproduce during the season in which they are born. In 14 litters the number of embryos ranged from three to six with a mean of 4. By including litters mentioned in the literature and on museum specimen labels one gets a range of two to six and mean of 3.69 for 26 litters. This means that each adult female is potentially capable of producing about 12 to 16 young per season.

Of the sexable embryos, there were 13 males and 14 females. The postnatal sex ratio shown by my collections was 128♂♂ : : 100♀♀, and the ratio in the Museum of Vertebrate Zoology collection 80.8♂♂ : : 100♀♀, the combined ratio being 88.0♂♂ : : 100♀♀.

Twenty-four embryos were found in the right and twenty-nine in the left uterine horns, while thirty-three recent corpora lutea were found in the right and forty-two in the left ovaries. In females that contained uterine swellings a wastage of two eggs was noted, but no cases of ova crossing to the opposite uterine horn were detected.

Pregnant females of *S. bachmani* probably do not copulate.

Ovarian structures resemble those of the domestic rabbit, and *S. bachmani* apparently develops corpora lutea atretica similar to those in *O. cuniculus*.

The minimum embryonic resorption rate was 12.5 per cent of the ovulations. This is probably several times smaller than the actual resorption rate.

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COTTONTAIL RABBIT INTRODUCTIONS AND DISTRIBUTION IN WESTERN OREGON

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During the summer of 1953 the writer's attention was called to a hitherto unrecorded and for the most part unknown introduction of the cottontail rabbit (*Sylvilagus floridanus* probably *mearnsi*) in western Linn County, Oregon. In the process of investigating this introduction, a second introduction was discovered in Benton County almost directly across the Willamette River, which forms an impassable barrier between the counties from the standpoint of rabbit distribution. Neither of these introductions has been thoroughly investigated. The presence of this rabbit in Linn County was apparently unknown to all but the original sponsors of this introduction. Apparently both introductions were made without the knowledge or consent of state authorities. Through fortunate circumstances it was possible to obtain fairly complete information on the Linn County introduction from a Linn County resident,

although the informant wished to remain anonymous. This information is accurate as to date, place, and origin of the introduction.

Sometime during May 1941, a number of Linn County sportsmen purchased 19 female and 6 male cottontails from an unidentified source in Illinois. They brought them to Linn County, where the entire lot was released near the Oakville Church in the rural community of Oakville, about 4 miles southeast of Corvallis, Oregon. It is not surprising that the presence of these rabbits has gone unnoticed for 12 years, for the redwood brush rabbit (*Sylvilagus bachmani ubericolor*) is commonly found in this area and unless viewed critically at short range or collected, the cottontails could easily be mistaken for brush rabbits.

While examining specimens of the western brush rabbit at the Museum of Natural History, Oregon State College, two specimens of the eastern cottontail in this collection were found from Benton County, north of Corvallis, about 6 miles northwest of the Oakville introduction. Through the kindness and help of Professor Jay Long of Oregon State College, it was possible to trace this introduction to its source. Mr. H. G. Steinel, Highland Avenue, Corvallis, Oregon informed me that his late father, C. C. Steinel had purchased six pairs of cottontails near Kent, Ohio sometime in 1937 and had personally brought them to his farm north of Corvallis. The rabbits were kept in pens for two years. During this time they multiplied to about 100, according to Mr. Steinel, and since their care had become a burden, they were all released on the family farm on Highland Avenue. This would place the point of introduction in Section 23, T.11 S. - R.5 W., and the date sometime in 1939. Accurate determination of the range extension of this population was not possible at this date, although a number of records were established through the help of the Museum of Natural History staff at Oregon State College, and these give some idea of the distribution of the Benton County population. Indications are that the distribution of the Linn County population equals that of the distribution of the Benton County population.

Throughout the month of July a careful mapping of the range extension of the Oakville introduction in Linn County was undertaken to determine how far it had spread, and to what extent spread was influenced by barriers and avenues of distribution. Records were plotted on a county road map as they were sighted while driving the country roads from sunup until about 8 a.m. All observations were made with an 18 x 50 binocular. Roads were systematically covered in an ever-increasing perimeter from the center of distribution and checked and rechecked until it was established with certainty that the maximum range extension had been determined.

Mr. Elmer Margasen of Shedd, Oregon, a long-time resident in Linn County and a highly interested sportsman, informed the writer that the cottontails had reached his farm, about one mile northeast of Shedd, about two years ago. His hunting observations had not placed the range extension farther than about one-half-mile east of his home during the 1952 hunting season. Later checks proved this information to be correct. This information also made it possible to start the mapping near the outer limits of the range.

It was quickly apparent that the easternmost extension of range was approximately due east of Oakville and in direct line with the most available

bridges, located on country roads crossing the Calapooya River. Undoubtedly rabbits could swim this and similar streams which run only 30 to 50 feet wide during the summer. However it is evident that wherever such a stream crossed the distributional avenues, bridges were apparently favored. This indicates that crossings by swimming are not favored or are not very successful. Flood-time, when a rabbit is most likely to be forced to swim a stream, is also the most unfavorable time from the standpoint of survival. Bridges at Corvallis, Albany, and Harrisburg lead directly into the cities and are probably not often used by cottontails. While the eastern distribution shows some influence of barriers, it appears quite normal and averages about one-half-mile per year for the past 12 years. It is the southward distribution that presents the most striking example of the influence of favorable avenues and of barriers in directing and forcing a population in a certain direction and beyond the normal yearly distribution.

The Oregon Electric Railroad right-of-way, running about one mile east of Oakville, is obviously an excellent avenue of distribution. It is little used by trains and the right-of-way on either side of the tracks is heavily overgrown with trees, shrubs, briars, and weeds. It affords a most excellent and continuous cover for the rabbits, as well as convenient bridges across streams. The Willamette River, about one mile west of Oakville, forces the population pressure to move either north or south and in this way the favorable cover of the river bottom also acts as a distributional highway. A second barrier to lateral distribution is formed by open fields along the railroad right-of-way and along the river bottom. These open fields range up to a section or more in extent and are probably most influential in forcing the range extension beyond normal limits along the railroad right-of-way. The fields are planted almost entirely to rye grass and cereal grains and are bare and uninviting from mid-summer until late spring, the very time during which the population pressure is greatest and mobility is at its highest in the rabbit population. The lateral distribution from the railroad right-of-way is along convenient brushy fence rows located at intervals from a few hundred yards up to a mile apart. It is immediately apparent that the chance that a wandering rabbit would strike one of these narrow lateral avenues is small in comparison with the probability of proceeding down the wider and safer continuous cover of the railroad right-of-way. Once past such a fence row, the rabbit would be virtually confined to the right-of-way cover until the next lateral fence row. It is not surprising then to find cottontails no less than 17 miles south of the original introduction site. It will be noted that the southernmost records, which show a skirting of the town of Harrisburg, are along small streams which provide the only good cover in the midst of otherwise extensive and barren fields of rye grass and grain. The Linn County introduction may be considered successful and the rabbits well established. A range of 175 to 200 square miles is indicated by 440 records. Rabbits were numerous throughout the area of distribution and were particularly common along the Oregon Electric Railroad right-of-way, even towards the more southern limits of the range where up to 10 rabbits could be seen along a 50-yard stretch of roadway at one time.

The Benton County population, on the basis of records obtained from Dr. Philip C. Dumas and Dr. Robert Storm of Oregon State College, indicates a

similar and equally successful range occupation. The most distant record from the original point of release was given by Dr. Philip Dumas. This rabbit was observed on Rocky Creek, just off State Highway 4, (Section 29, T.12 S. - R.6 W.) southwest of Philomath, a distance of about 10 miles from the original liberation site. This portion of Benton County presents a more continuous habitat with fewer barriers in the form of large open fields and large streams than does Linn County, and distribution is probably more uniform and continuous than in Linn County. Mr. Steinel stated that these introduced cottontails were common in the vicinity of Lewisburg, about 5 miles north of Corvallis. All indications point to an establishment of the eastern cottontail in Benton County over an area probably equal to that in Linn County and equally successful.

From the standpoint of game, this rabbit should be a welcome addition to the Willamette Valley fauna. The redwood brush rabbit provides no hunting. It is not numerous in the valley and its habit of sticking close to its minute territory in some dense thicket makes it almost impossible to hunt except by stalking early in the morning or late evenings. At these times it is extremely vulnerable and easily taken. Their habits and habitat make them quite unsuitable for beagle hunting. The blacktailed jackrabbit, (*Lepus*) has, since the middle 30's, declined to the extent that there is little or no hunting. In over 2000 miles of driving on Linn County roads during the month of July, only two dead jackrabbits were observed. No live ones were seen early in the morning while checking cottontails. During the early thirties the writer hunted this area extensively and any 10-mile stretch of country road would have produced at least two dead rabbits. The change to highly mechanized farming practices and to greater use of irrigated pastures has led to a decided decline in horse and cattle pastures, characterized by open woods and uncultivated fields which were highly favored by the blacktail jackrabbits. Timber areas with fairly open ground cover, such as old second growth stands of Douglas fir also have decreased materially as a result of an increase in stumpage prices in recent years. Once logged, these lands quickly grow up to a dense almost impenetrable cover of shrubs, briars, and young second growth Douglas fir, a cover that is quite unsuitable for jackrabbits, which prefer the more open forest floor of the older stands of timber. The heavy cover following logging is however, very well suited to the cottontail. In addition, the numerous brushy fence rows and creek bottoms provide ideal habitat. This, and the fact that the cottontail will leave its cover and take to the open fields and clearings when driven by dogs or even when the cover is worked by hunters alone, and the fact that it is more commonly accepted by the Westerner as table game which can be eaten, while the jackrabbit is not, adds to its desirability as a game species.

Concern has been expressed by persons from time to time that these rabbits may become a problem through overpopulation. Since disease and parasite factors differ little from the eastern environment there is little chance that these rabbits will increase beyond their normal density as found in eastern states. They are, however, much more numerous than the native rabbits in these areas and in the course of the investigation some attention was given to the possibility of crop damage, particularly in vegetable gardens. Damage to grain fields, if any, would be so small

that it would go unnoticed. Mr. H. G. Steinel, of Corvallis, Oregon, was questioned in regard to garden damage. Certainly he would have had reason to complain, having had the rabbits on his place for some 14 years. He stated that while rabbits were always present in and about his garden and had access to it, he could determine no damage worth complaining about. Some plants or groups of plants, were at times browsed and localized damage did occur, but as a whole the production of his garden was not affected. A second garden, about 50 by 60 ft. in area, because of small size and heavy adjoining cover, was particularly vulnerable to damage by the rabbit population which is known to exist in the bordering cover. At least two rabbits were observed in this garden almost every day during the month of July. Some feeding was done on garden plants, but was so sporadic that little damage was done. The owner stated that during the past year beans had been eaten rather selectively but this stopped when the plants were heavily dusted with rotenone. The same thing occurred this year when the young muskmelon vines were damaged. Indications are that for the most part garden feeding is so sporadic that little damage results except in isolated instances. The reaction to the use of rotenone indicates the possibility of protection through the use of a repellent.

In conclusion it should be stated that too little attention has been given to the role played by barriers and avenues of distribution in the introduction of exotics. Students and game biologists must become more aware of these and other factors which may play a most important role in effecting or controlling the introduction of a species.

SUMMARY

1. The eastern cottontail, (probably *Sylvilagus floridanus mearnsi*) has been introduced successfully in two western Oregon counties, Benton and Linn County. Both introductions appear to be highly successful and in Linn County an area of 175 to 200 square miles has been occupied. Indications point to the occupation of a similar area in Benton County.

2. The Linn County area shows a considerable difference in direction of spread due to a combination of favorable avenues of distribution and barriers which have forced the spread to extend 17 miles south of the original site of introduction as compared to only 5 to 6 miles east and north.

3. From the standpoint of hunting, these rabbits should prove successful since they can be hunted with dogs or by driving. No native rabbit now provides hunting in the Willamette Valley. The acceptance of this rabbit for table use places it in a favorable category as a game animal.

4. Crop damage on a large scale is not indicated under the present type of farming. In small gardens, damage is at present not noticeable or could be controlled locally with repellents or by shooting where necessary.

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NESTING STUDIES OF THE COOT IN SOUTHWESTERN MANITOBA

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The nesting-season data on the coot (*Fulica americana*) reported here were gathered in conjunction with a project designed to study duck production in prairie pothole habitat. This paper discusses the phenology, population and nesting trends, habitat preferences, and nest histories of coots on a study area in southwestern Manitoba during the 4-year period, 1949–1952.

Although the coot is an important game bird in the Mississippi and Atlantic flyways and rates high numerically in the continental waterfowl population (Crissey, 1951; Williams, 1952), I found nesting studies of this species reported only for Iowa (Friley, Bennett, and Hendrickson, 1938; Sooter, 1941; Provost, 1947).

Acknowledgments

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I wish to express appreciation to the following people who assisted materially in some of the field work: E. N. Cole, Glenn Parsons, R. B. Iliffe (Manitoba Game Branch); J. B. Gollop (Canadian Wildlife Service); W. C. Newcomb (U. S. Fish and Wildlife Service); and Alexander Dzubin (University of British Columbia). Others who worked in the field at some time are G. K. Brakhage, R. W. Balham, D. E. Sutton, S. T. Dillon, G. P. Dellinger, A. J. Reeve, and J. H. Stoudt.

Advice and helpful criticism were generously given by R. A. McCabe, J. J. Hickey (University of Wisconsin), and H. A. Hochbaum (Delta Waterfowl Research Station). I am especially indebted to A. S. Hawkins (U. S. Fish and Wildlife Service) for encouragement, field assistance, and advice throughout the study.

The Study Area

The district studied lies south of Riding Mountain National Park in aspen parkland. Ellis (1938) described the soil zone as northern black earth and degrading northern black earth formed on glacial till. The topography is gently rolling with water areas or sloughs called potholes in the depressions. In portions of the district, the density of potholes exceeds 100 per square mile. The land is fertile and heavily utilized for growing small grain or for grazing.

Potholes tend to increase in size toward the northern limit of the district. Therefore, the 4,000 square-mile study area, lying further north than the bulk of Manitoba's pothole country, contains better-than-average waterfowl habitat in terms of size and permanency of water areas. This district was selected for study because several transects, es-

tablished by the U. S. Fish and Wildlife Service in 1947, provided background for the study of waterfowl production. Twelve transects were established in April, 1949, under the direction of A. S. Hawkins, who has conducted waterfowl breeding surveys in Manitoba since 1946. The transects followed roads and were located to sample the various habitat types within the district. Each transect was one-fourth mile wide. The total area of the twelve transects was 50.4 square miles. For more intensive study, 120 potholes were selected randomly from the semipermanent and temporary potholes on the transects. Hereafter, the 120 potholes in this sample will be referred to as study potholes.

Permanency ratings of potholes follow those reported by Bach (1951) for North Dakota. The system classifies water areas as *permanent* (lakes with wave-swept shores); *semipermanent* (potholes retaining water except during drouth periods); *temporary* (potholes drying up by July–August of a normal year); and *runoff puddles* (resulting from melting snow or heavy rains, short-lived, and without aquatic vegetation). Man-made "dugouts", which catch runoff for stock watering, are a separate class found either as distinct water areas or at the edge of potholes of the above permanency ratings.

PHENOLOGY OF THE NESTING SEASON

The phenology of waterfowl breeding seasons in Manitoba for the period, 1949–1952, has been discussed by Hawkins (1949, 1950); Hawkins, Wellein, and Gollop (1951); Hawkins and Wellein (1952); and others. Considering such factors as waterfowl arrival, first-egg and hatching peaks, plant growth, and seeding and harvesting operations on farms, the general phenology can be described as follows: 1949—about normal; 1950—two to three weeks late; 1951—less than a week late; and 1952—less than a week early.

Water conditions of the study potholes varied considerably during the study (Table 1). In 1950, water levels were high in the spring and remained high through the season. The larger potholes (3–10 acres) entered the 1951 season with high water levels, but smaller potholes were low. A wet fall and a winter of light snowfall preceded these spring water conditions in 1951. Semi-drouth in 1952 resulted in deterioration of pothole habitat to the extent that by May 15 runoff puddles were nonexistent and approximately 40 per cent of the temporary potholes on transects were dry. In many cases, water levels in the semipermanent potholes, which are preferred coot nesting areas, had receded, leaving the nesting cover on dry ground.

TABLE 1.—WATER CONDITIONS AND SPRING-BURNING HISTORY OF 120 POTHOLES

Pothole Condition	Per Cent by Years			
	1949	1950	1951	1952
Burned in spring	?	3	23	29
Dry by May 31	0	0	2	20
Dry July 8–25	0	0	19	45
Dry by September 1	26	3	40	?

Dry spring weather in 1951 and 1952 permitted farmers to do an abnormal amount of spring burning around potholes (Table 1). Burning edge vegetation usually does not destroy the emergent aquatics used by nesting coots but does affect ducks nesting near pothole margins. In 1952, however, water levels were so low that even emergent plants such as cattail (*Typha latifolia*) and bulrush (*Scirpus acutus*) were damaged severely by fire. Coots, notably, were not nesting in these stands left on dry ground or in very shallow water; hence,

their nests were not destroyed by burning.

Indicators of seasonal phenology are coot arrival dates and hatching peaks (Table 2). The pattern of arrival may

TABLE 2.—COOT ARRIVAL DATES AND HATCHING PEAKS

	1949	1950	1951	1952
Arrival dates.....	April 21–22	May 8	April 26–27	April 20–24
Two peak hatching dates	June 8,9	June 18,23	June 10,11	June 1,4
Interval between arrival and hatching peak (days).....	47–49	41–46	44–46	38–45

vary with other weather conditions, but in four years of study, the principal coot migration, including the first arrivals, occurred within one-to-five-day periods. Coots arrived at night. Calls of the night-migrating birds gave striking notice of their arrival. Sooter (1941), in Iowa, reported observations which indicated that coots migrated at night.

Hatching curves based on successful nests point out the lateness of the 1950 season (Fig. 1). In each of three years—1949, 1951, and 1952—approximately 80 per cent of the successful nests hatched before June 16. In 1950, no hatched nest was found before that date. The earliest hatching date recorded was May 31, 1952; the latest was August 8, 1950. Since a coot clutch usually hatched over a period of four to five days, the hatching date for a nest as used in this study is defined as the date the first egg of the clutch hatched. Excluding 1950, the hatching period lasted about one month with 82 per cent of the successful nests hatching during the first 15 days of the period.

Spring breeding-ground surveys to determine trends in coot populations face the problem of phenological adjustment from year to year. On the basis of coot

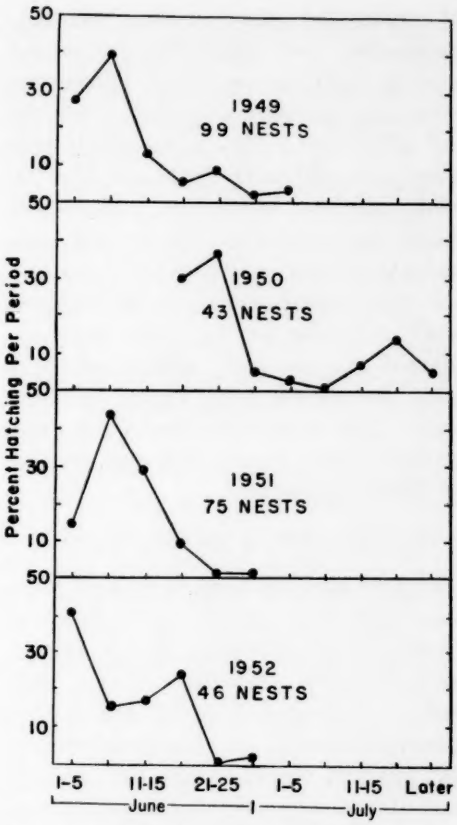

FIG. 1. Hatching curves of successful nests. May 31 is included in the June 1–5 period in 1952.

arrival dates and hatching peaks found in this study, it seems that the period, May 1–10, would be a good time to census coots except in phenologically late years. This interval includes the time between arrival and first-egg laying.

Second peaks indicated in the hatching curves of 1949 and 1952 might be due to an ingress of breeding coots from drouth areas where nesting habitat had deteriorated. Southern Saskatchewan was dry in 1949 (Lynch, 1949), and southwestern Manitoba developed semi-drouth conditions in 1952. It should be emphasized that the study area has better-than-average habitat in terms of semipermanent potholes. In 1951, a year

of satisfactory water levels in both Saskatchewan and Manitoba, no second peak in hatching was found. During the unusually late spring of 1950, coots did not arrive until May 8, and large potholes were still partly frozen on May 11. Such adverse conditions conceivably could have disrupted the normal coot nesting pattern in that year. In view of the high nesting success to be discussed later, renesting by the birds originally present is practically eliminated as a cause for second peaks in the hatching curve. The possibility that some coots produced two broods was not verified by field observations.

POPULATION AND NESTING TRENDS

Census methods used on ground transects and study potholes were designed primarily to determine trends in the duck breeding population. Coots, however, were included in the counts. On ground transects, waterfowl were counted on potholes within one-eighth mile of each side of the road. Potholes partially or entirely obscured from view by rims of willow (*Salix* spp.) and aspen (*Populus* spp.) or by topographical obstacles were covered by walking to some vantage point from which the entire pothole could be scanned with a binocular. No attempt was made to flush birds from cover.

Study potholes, however, were searched in a manner designed to attain a complete census, if possible, by flushing ducks from cover. Coots reacted to disturbance by hiding in emergent vegetation and refused to be ousted by efforts effective for flushing most ducks. Since the census techniques designed for ducks were not equally effective in counting coots, only an index to the coot population was obtained.

This index serves to measure trends in populations provided censuses are comparable from year to year. Habitat conditions varied; hence census conditions were not the same from year to year. For example, low water levels in 1952 made coots more conspicuous because the zone of emergent vegetation affording cover was narrowed. Dense vegetation and high water levels as found in 1951 made censusing more difficult.

Trends in the coot population index on transects and study potholes are presented with the above limitations (Fig. 2). The decline in breeding coots from

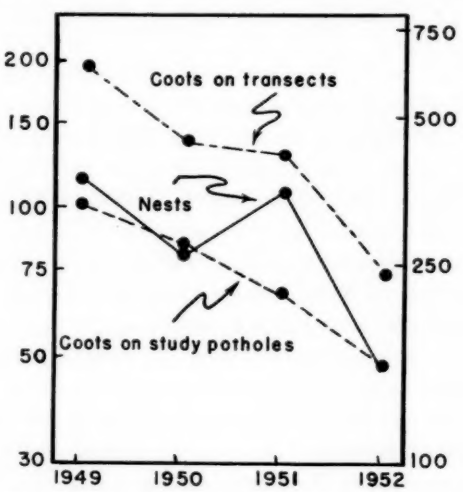

FIG. 2. Trends in index populations of coots and number of nests (plotted on semilogarithmic scale). The left-side scale indicates number of nests and coots on study potholes; the right-side scale represents coots on transects.

1949 through 1952 was 62 per cent on transects and 53 per cent on study potholes.

Nest-finding techniques and effort were comparable from year to year. The emergent vegetation of study potholes was searched systematically for nests several times each nesting season. A small percentage of nests was missed as evidenced by the fact that of 351 nests believed to be on the area, 338 were actually found. The additional 13 were based

on evidence provided by the presence of adult coots on a pothole during the nesting season followed by the presence of a coot brood less than one week old on the same pothole later in the season. The influence of renesting on the total number of nests found in a given year was not great because of the high nesting success which averaged 97 per cent for four years.

Trends in nesting also are illustrated in Figure 2. The number of nests on study potholes decreased 58 per cent during this 4-year study. A sharp drop in number of nests in 1950 accentuates the 1951 peak. It is possible that adverse weather such as frost, snow, and cold, driving rain during the early portion of the 1950 nesting season reduced the number of nesting efforts by coots in that year. On the other hand, 1951 apparently was an excellent nesting season with favorable weather and water conditions.

Through 1951, the breeding population indices indicated a downward trend in coots. In 1952, a year of semidrouth in southwestern Manitoba, the index to coots on transects dropped sharply as did the number of nests on study potholes. This decrease was not a local phenomenon of the study area, since coots were drastically reduced on a province-wide basis (Kiel and Hawkins, 1953). Whether the marked decline in this district was due to a decrease in the over-all coot population or to a shift of breeding birds to better habitat is not known. The region of pothole habitat in southern Saskatchewan just west of the study area had adequate water in 1952.

NESTING HABITAT

In an attempt to evaluate the role of many types of potholes in waterfowl production, permanency ratings as previously discussed, vegetative types, and size classes were used to describe potholes in this study. The four broad vegetative types found were sedge (*Carex* spp.)—whitetop (*Scolochloa festucacea*), cattail, bulrush, and willow. Sedge, principally *Carex rostrata*, and whitetop were most often found in mixed stands and seemed to be on a par as nesting cover for coots. A more detailed breakdown of vegetative types was made, but this discussion will be confined to these four types. The criterion for a cattail pothole was the presence of more cattail nesting cover than any other type in the pothole.

Size in acres was determined by pacing and estimating distances. During the course of the study, acreage estimates were checked several times. Pothole marginal zones of spike rush (*Eleocharis* spp.), *Juncus* spp., sedge, and whitetop generally were growing in water in early spring and in wet years and were included as part of the pothole area. Wild barley (*Hordeum jubatum*), commonly found just outside these zones, was not included in acreage estimates.

Temporary potholes attracted nesting coots only in the comparatively wet springs of 1950 and 1951 (Table 3). The temporary areas used for nesting in those two years retained water throughout the breeding season. As a whole, the small size and temporary nature of these potholes together with a general lack of cattail or bulrush cover seemed to make them unattractive to coots. It was not

TABLE 3.—SIZE AND NESTING USE OF SEMIPERMANENT AND TEMPORARY POTHOLES

	Pothole Permanency		
	Semipermanent	Temporary	Total
Number of potholes	67	53	120
Mean size* (acres)	2.8±0.4	0.6±0.1	1.8±0.2
Number of nests			
1949.....	114	0	114
1950.....	76	5	81
1951.....	105	3	108
1952.....	48	0	48

* ± standard error of mean.

unusual to find deserted nests of over-water-nesting ducks in sites left dry by receded water levels, but none of the coot nests observed were found in such locations. In contrast to some species of ducks, coots did not nest in potholes which later dried out.

In semipermanent potholes, coots preferred cattail and bulrush cover for nesting (Table 4). Isolated stands of cattail and/or bulrush adequate for coot nesting cover were present in 11 of the 29 nest-occupied sedge—whitetop potholes. In four of these 11 potholes, the cattail or bulrush stands contained the only nest or nests in the pothole for at least one season. The tendency for large potholes within a preferred vegetative type to be occupied more consistently than small potholes is indicated by the pattern of occupancy of cattail potholes. Factors other than size and cover type which have bearing on the attractiveness of semipermanent potholes to nesting coots probably include density of emergent vegetation (often affected by grazing pressure), food availability, water depth, amount of willow and/or aspen surrounding pothole, and location in respect to other potholes in the vicinity.

The average density of nests in semipermanent potholes was 0.6 nests per acre in 1949. One cattail pothole of 2.4 acres contained nine nests, one of which was broken up, possibly because of intraspecific strife. Some other areas of similar size or even larger, but without good nesting cover, had no nests.

As mentioned earlier, the coot population index decreased in this district from 1949 through 1952. Following 1950, a wet year, water levels receded gradually in 1951 and approached semidrouth in 1952. Figure 3 shows that with a declining breeding population and semidrouth conditions, the mean size of potholes used by nesting coots increased; or, in other words, the tendency for smaller,

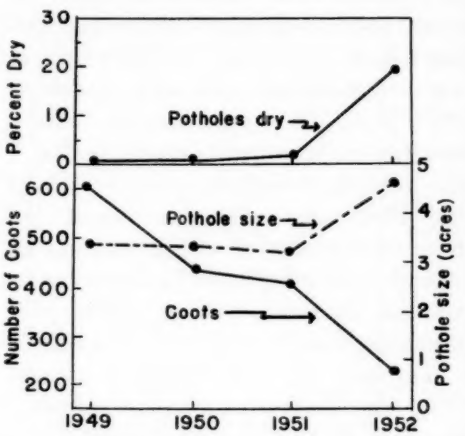

FIG. 3. Trends in (1) percent of 120 study potholes dry by May 31; (2) mean size of study potholes having nests; and (3) index to coots on 12 transects.

TABLE 4.—NESTING USE OF VEGETATIVE TYPES AND SIZES OF SEMIPERMANENT POTHOLES
The mean sizes of potholes in acres are given according to years occupied.

Years Occupied	Vegetative Type of Pothole														
	Sedge—Whitetop			Cattail			Bulrush			Willow			All Types		
	%	No.	Size	%	No.	Size	%	No.	Size	%	No.	Size	%	No.	Size
4.....	9	4	6.3	71	12	3.9	100	2	8.6	.....			27	18	4.9
3.....	17	7	2.4	17	3	2.1	.....			17	1	8.0	17	11	2.8
2.....	12	5	1.7	12	2	0.8	.....			17	1	0.6	12	8	1.4
1.....	31	13	2.4	.....			.....			33	2	1.3	22	15	2.3
0.....	31	13	2.0	.....			.....			33	2	0.3	22	15	1.7
Total.....	100	42	2.5	100	17	3.2	100	2	8.6	100	6	2.0	100	67	2.8

less-permanent potholes to be unoccupied increased. A consideration of 1949, 1950, and 1951 reveals that, despite a 32 per cent drop in population since 1949, no increase in mean size of pothole used is indicated in either 1950 or 1951. Water conditions were normal or above during the same period. With the onset of semidrouth in 1952, and a continued decline in population, mean size of potholes used increased. Under these conditions, a number of factors possibly could cause such a change in type of pothole used, but deterioration of habitat in the smaller potholes appears to be the most likely reason.

NESTING HISTORY

Coot nests were distributed in four cover types on study potholes (Table 5). Sedge—whitetop was the most abundant nesting cover, followed by cattail, bulrush, and willow. Cattail and bulrush cover was more heavily used in proportion to availability than was sedge—whitetop. Since coots generally completed their nests by May 15, less than two per cent were built in new growth, and those were in bulrush in the late nesting season of 1950.

Cover availability varied with fluctuating water levels. To illustrate, 1950 was a wet year with high water levels which promoted profuse plant growth around pothole margins. Water levels remained high in semipermanent potholes through the early spring of 1951, and nesting coots made unusually heavy use of this dense pastseason growth of sedge and whitetop. In 1951, 52 per cent of the nests were in sedge—whitetop cover compared to an average of 31 per cent in that cover type for the other three years. Under the semidrouth conditions of 1952, only 23 per cent of the total number of coot nests were found in sedge—whitetop cover, a reflection of a trend toward increased use of cattail and bulrush which usually grow in deeper water of the more permanent potholes.

Nesting success of coots was 97 per cent of 380 nests with complete histories over the four years, 1949–1952 (Table 6). A nest was considered successful when one or more of the eggs hatched. A

TABLE 5.—PERCENTAGE USE OF NEST COVER TYPES ON STUDY POTHOLES

Year	1949	1950	1951	1952	4 years
No. of Nests	107	78	104	48	337
Cover Type (%)					
Sedge-whitetop	31	35	52	23	37
Cattail	49	49	36	50	45
Bulrush	16	11	7	23	13
Willow	4	5	5	4	5
Total	100	100	100	100	100

TABLE 6.—COOT NESTING STATISTICS

		1949	1950	1951	1952	4 Years
Nesting Success	No. nests	152	69	103	56	380
	% successful	95	93	100	98	97
Clutch Size	No. clutches	103	20	30	16	169
	Range	5–13	7–12	9–13	6–10	5–13
	Mean*	9.8±0.2	10.1±0.3	10.7±0.2	8.8±0.3	9.9±0.1
Egg Hatchability	No. nests	82	17	28	14	141
	No. eggs	798	172	298	126	1,394
	% hatched	99	100	99	100	99

* ± standard error of mean.

hatched nest was characterized by a distinct layer of small egg-shell chips, most often found underneath several layers of nest lining. Kozicky and Schmidt (1949) reported similar characteristics for hatched clapper rail (*Rallus longirostris*) nests in New Jersey. In contrast to hatched duck nests, egg membranes were seldom present in coot nests to indicate successful hatching. Sowls (1951) showed that ducks carry broken eggs from the nest during incubation. Since the coot hatching period is prolonged, perhaps the shells and membranes of hatched eggs were carried from the nest. Such behavior was not observed, however. Unless examined closely, nests might be confused with platforms which resemble nests but are constructed more loosely and not lined with fine portions of nest material.

Only 13 nests were unsuccessful. It was difficult to determine the primary cause for a nest failure. Signs at the nest indicated that birds, probably crows (*Corvus brachyrhynchos*) and/or magpies (*Pica pica*), destroyed five nests; mammals took two; five were destroyed by unknown predators; and one clutch of nine eggs was infertile or addled.

Clutch sizes have been reported by Friley, Bennett, and Hendrickson (1938) and Sooter (1941) in Iowa, but apparently no distinction was made between complete and incomplete or partially-hatched clutches. Also in Iowa, Provost (1947) found that 37 complete clutches ranged from 6 to 14 eggs and averaged 8.8 eggs per clutch. For the four years of this study in Manitoba, the mean clutch size of 169 complete clutches was 9.9 eggs with a range from 5 to 13 eggs per clutch (Table 6). The smaller mean clutch size of 8.8 eggs in 1952 coincided with a season marked by a second peak in hatching (Figure 1) possibly caused by a late influx of coots from semidrouth areas. If these coots failed in an earlier nesting attempt, the nesting effort in the study area would represent renests with smaller clutches. Conversely, the 1951 season appeared to be ideal for nesting with no indication of a second peak in hatching, and the mean clutch size (10.7) was higher than in any of the other three years.

Egg hatchability was 99 per cent of 1,394 eggs in successful nests with complete clutch counts (Table 6). It seems unlikely that coots removed from the nest unbroken eggs that failed to hatch.

A comparison of the nesting success of coots, diving ducks (generally over-water nesters), and dabbling ducks (generally land nesters) on the study area shows an upward gradient in success from dabbling ducks through coots (Table 7). These statistics do not separate renests from first nests. It appears that in pothole habitat, nesting over water is a distinct advantage because nests are largely protected against land-dwelling mammals and yet are not subjected to danger of destruction by wave action, which is reported by Sooter (1941) as important on larger, open-water areas. Some aquatic mammals, avian predators, and fluctuating water levels are potential nest destroyers, however. Whether a cold, wet spring, often associated with poor reproductive success in waterfowl, is more detrimental to ground nesting or over-water nesting

TABLE 7.—A COMPARISON OF COOT AND DUCK NESTING SUCCESS

Year	Coots		Diving Ducks		Dabbling Ducks	
	No. Nests	% Success	No. Nests	% Success	No. Nests	% Success
1949....	152	95	78	65	48	46
1950....	69	93	35	71	21	52
1951....	103	100	61	87	32	56
1952....	56	98	53	68	48	50
4 years..	380	97	227	73	149	50

species is not known, but it seems that ground nesters suffer greater nest losses.

The coot has additional attributes for nesting success. Sooter (1941), using three marked birds, found that both sexes incubate. Coots were observed changing shifts at incubation duties in this study. The advantage for nesting success gained by both sexes incubating is supplemented by the coot's aggressive nature which probably discourages most avian predators.

SUMMARY

Coot nesting was studied for four years, 1949–1952, in a pothole area in southwestern Manitoba. Transects and study potholes yielded data on population and nesting trends.

Phenologically, 1949, 1951, and 1952 were similar. Semidrouth conditions developed in 1952. The 1950 season was two to three weeks late and exceptionally wet.

Coots arrived during the last 10 days of April, except in 1950, when first arrivals appeared May 8. The peak of hatching occurred from 38 to 49 days later. The earliest hatching date recorded was May 31, 1952; the latest was August 8, 1950. Approximately 80 per cent of the successful nests hatched before June 16 in 1949, 1951, and 1952. In 1950, no hatched nest was found before that date.

It is suggested that in normal years the period May 1–10 would be a good time to census coots in this region. There is a possibility that coots from drier areas moved into the study area to nest in the seasons of 1949 and 1952.

Census techniques were designed primarily for ducks and provided only an index to measure trends in the coot population. These indices indicated declines in breeding coots from 1949 through 1952 of 62 per cent on transects and 53 per cent on study potholes. Number of nests decreased 58 per cent during the same period. The sharpest drop in population and nests occurred in 1952 under semidrouth conditions. It is not known whether a decline in the over-all coot population or a shift of birds to better habitat were jointly or singly responsible for this decline.

Coots nested in temporary potholes only in the comparatively wet springs of 1950 and 1951. Semipermanent cattail and/or bulrush potholes were preferred by nesting coots. Under the conditions of a declining population and semidrouth in 1952, the mean size of potholes used increased. Apparently, deterioration of habitat in the smaller potholes caused this change.

Cattail and bulrush were the preferred cover types for nesting. Fluctuating water levels affected the availability and attractiveness of some cover types, particularly sedge—whitetop.

Nesting success of coots was 97 per cent of 380 nests over the 4-year period. The mean clutch size of 169 complete clutches was 9.9 eggs. Egg hatchability was 99 per cent of 1,394 eggs in successful nests with complete clutch counts. Coots had higher nesting success than over-water-nesting (73 per cent) or land-nesting (50 per cent) species of ducks on the study area.

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A METHOD FOR NUTRITIONAL EVALUATION OF WILDLIFE FOODS

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This paper deals with the nutritional values of wildlife foods in relation to their utilization. The information contained herein is based on work done by J. R. Beck on wild turkeys of the King Ranch, Texas.

The authors wish to express their appreciation to Dr. Ruth Reder and Prof. R. H. Thayer of Oklahoma A. & M. College for their cooperation and assistance in the preparation of this paper.

By present methods of evaluation, the foods of upland game birds are evaluated either on a frequency or volumetric basis (Martin, Gensch and Brown, 1946). Such methods are sometimes inadequate for reliable application to wildlife management. The following material is an attempt to eliminate some of the problems involved in food habits research.

ANALYSES AND RESULTS

The foods used for the chemical analysis were taken from the crops of wild turkeys (*Meleagris gallopavo*) collected

on the King Ranch. The methods used for the proximate analysis of these foods are those given by the Association of Official Agricultural Chemists (1935). The methods of mineral analysis follow those used by Reder *et al.* (1951).

It was necessary to oven-dry some foods, such as *Celtis pallida*, *Opuntia leptocaulis*, and *Insecta*, before grinding them for the proximate analysis. However, none of the foods are presented on a moisture-free basis.

The method used for determining the amounts of calcium and magnesium present (Reder *et al.*, 1935) is recommended for use only when there is a small amount of the minerals present, preferably .12 to .16 mg. per sample. The determination of larger amounts is less accurate. The concentration of calcium in some foods appears unduly high, but, on the other hand King and McClure (1944) also obtained a high concentration of calcium from some seeds taken near San Antonio, Texas. The calcium values they found correspond closely with the values presented herein.

Only foods taken in large quantities were analyzed. Green matter was the exception; for while it occurred in the crops in large amounts, it could neither be satisfactorily preserved nor kept fresh. No vitamin analyses were made due to the lack of fresh samples of the foods.

The results of proximate and mineral analyses are reported in Table 1, which is similar to that published by Spinner and Bishop (1950). The plant names are in accord with Fernald (1950) and Hitchcock (1950).

Many of the weeds, such as *Croton*, *Verbesina*, and *Senecio* were very high in energy - giving and body - building foods. As expected, the animal matter is high in protein with the exception of snails, which because of their shell are high in ash or mineral content. Iron was present in large quantities in a few plants. Another mineral, iodine, was not found in any of the foods, but this does not necessarily prove an iodine deficiency in wild turkey foods.

APPLICATION

The analyses of these foods would be of limited value if they could not be correlated with the nutritional requirements of turkeys.

The nutritional requirements of wild turkeys are not well known, but, on the other hand, the requirements of domestic turkeys are reasonably well established. The requirements of wild turkeys given herein are based on the minimum standards for domestic turkeys given by Marsden and Martin (1949) and Cline (1936). This is not as great an assumption as it might seem because pen-raised wild turkeys do well on feeds which meet the minimum requirements for domestic turkeys (Greenberg, 1949). The minimum nutritional requirements of wild turkeys may not, however, be as high as those indicated for domestic turkeys because the requirements are set up to achieve maximum egg production and great weight. Therefore, the term "minimum standard" will not be used. The term "standard" will be used to denote a diet that is known to be adequate.

The requirements of turkeys vary with age and season; therefore, it is necessary to use nutritional standards for three types of diets. Besides the diet needed for normal body maintenance, which includes fattening, there are also diets for breeding turkeys and growing poults. Minimum requirements of the three diets are given in Table 2.

The foods analyzed were compared individually with the above standards

TABLE 1.—PROXIMATE AND MINERAL ANALYSIS OF THIRTY-NINE WILD TURKEY FOODS

Name	Water	Ash	Oil	Crude Fiber	Protein	Nitrogen-free extract	Calcium	Phosphorus	Magnesium	Iron	Zinc
	(%)										
Agrostis hiemalis	5.04	44.03	1.40	7.82	9.06	32.65	1.647	0.330	2.986	5.0	0
Brachiaria ciliatissima	7.05	10.61	5.04	20.91	14.00	42.39	.650	.410	.312	0	T
Celtis pallida	30.24	20.38	2.00	7.24	10.64	29.50	.609	.200	.742	0	0
Celtis reticulata	4.42	45.70	4.36	10.03	13.69	21.80	17.280	.315	23.400	0	0
Cephalanthus sp.	6.56	6.30	11.40	38.40	13.13	24.21	1.725	.205	2.120	.05	0
Chloris (2 species)	7.08	16.11	2.84	24.20	18.38	31.39	.826	.368	1.124	2.0	T
Condalia spatulata	47.65	4.97	4.68	15.65	6.62	20.43	1.015	.074	1.453	0	T
Cottonseed cake	12.33	11.85	0.45	10.62	40.96	23.79	.855	1.062	1.276	0	0
Croton glandulosus	6.58	7.35	6.47	6.71	19.88	53.02	1.728	.300	1.083	.125	0
Croton lindheimeri	5.76	5.62	9.42	14.69	20.94	43.57	.840	.352	.860	0	0
Croton texensis	8.75	3.27	18.00	17.80	19.28	32.70	.530	.418	1.320	0	0
Cyperus rotundus	9.86	13.88	2.94	10.44	17.00	45.88	1.722	.440	1.795	.25	0
Euphorbia sp.	5.84	10.30	6.86	23.26	17.50	36.24	1.728	.420	1.106	.25	0
Fagara fruticosa	12.62	8.94	0.82	33.20	9.69	34.73	1.722	.130	2.585	0	0
Galactia grayii	7.26	4.96	4.62	11.42	18.06	53.68	1.442	.295	2.769	0	0
Jatropha spatulata	6.58	4.94	0.78	10.84	9.63	67.23	1.728	.295	3.505	0	0
Lantana horrida	37.87	5.21	2.33	40.56	6.21	7.82	1.060	.120	1.270	0	0
Nicotiana sp.	6.65	7.06	10.35	28.94	20.58	26.42	1.722	.520	3.094	0	0
Opuntia leptocaulis	80.05	2.69	0.80	5.94	2.80	7.72	.354	.076	.610	0	T
Opuntia lindheimeri	8.02	14.70	7.96	37.00	7.94	24.38	1.716	.330	1.838	T	T
Palafoxia texana	5.66	8.41	15.42	24.20	18.48	27.83	1.716	.420	2.488	0	0
Panicum firmulum	6.50	8.84	2.98	24.13	12.09	45.46	1.728	.325	1.287	0	0
Paspalum (3 species)	6.61	4.26	2.54	31.52	11.82	43.25	.861	.295	.984	0	T
Pyrrhopappus multicaulis	5.73	15.77	6.30	9.69	17.61	45.00	.858	.495	.508	T	0
Prosopis juliflora	15.67	3.18	3.04	23.20	10.82	44.09	1.018	.130	1.340	0	0
Quercus virginianus	28.98	3.50	1.84	16.52	5.61	44.00	.862	.155	1.509	.125	0
Senecio ampullaceous	7.00	8.14	18.23	17.53	17.81	31.29	1.722	.565	1.472	.05	T
Setaria (2 species)	8.17	8.16	2.74	21.32	13.28	46.33	.192	.390	.810	0	0
Tricachne patens	7.52	7.67	3.76	24.16	19.00	37.89	1.716	.315	1.838	T	0
Vaseyochloa multinervosa	8.00	10.92	3.36	21.78	13.09	42.85	1.725	.420	1.157	.05	0
Verbesina enceloides	6.82	8.24	17.58	24.76	23.22	19.38	1.722	.480	2.228	0	0
Vicia sp.	8.40	10.90	2.57	19.17	16.44	42.52	3.450	.340	4.846	0	0
Vitis mexicana	8.77	3.61	8.19	26.27	12.16	41.00	1.722	.375	1.488	.025	0
Xanthoxylum clava-herculis	9.16	5.28	31.66	30.46	13.05	10.39	1.728	.385	2.314	0	T
Insecta											
Beetles	31.69	3.77	2.99	21.99	40.66	0.00	1.208	.168	1.344	.05	0
Grasshoppers	28.27	5.41	2.74	11.02	45.34	7.22	1.279	.204	1.605	.05	0
Larvae (Lepidoptera)	40.45	2.37	2.81	12.01	26.69	15.67	1.050	.143	1.458	0	0
Misc. and Spiders	29.48	1.83	1.68	15.27	49.30	2.44	1.308	.258	2.014	.10	0
Snails (2 species)	2.61	84.25	0.48	1.41	9.81	1.44	17.280	.480	20.760	.10	0

to determine their nutritional value. Almost all of the foods met the crude fiber and water allowances, so these two factors were discarded. Thus, only the proportions of protein, ash and energy foods were used in evaluating the results of the chemical analyses (Table 1).

Determination of the percentage of the protein requirements met by the foods is simple. For example, *Celtis reticulata* contains 13.7 per cent protein which meets 81 per cent of the requirement for breeders and 105 per cent of the protein needed for maintenance. In the latter case, the extra five per cent is not to be disregarded in evaluation, because extra protein is used as energy.

In determination of the percentage of the energy food requirements met both carbohydrates and fats are involved. First, the percentage of the fat requirements must be determined. Any extra

TABLE 2.—NUTRITIONAL ELEMENTS REQUIRED BY TURKEYS FOR AN ADEQUATE DIET [1]

Nutritional Element	Breeder diet	Maintenance diet	Growing poult diet
Protein	17(%)	13	24
Ash	5	3	4
Calcium	(2.2)	(1.0)	(1.6)
Phosphorus	(0.7)	(0.3)	(0.5)
Fat	4	2	4
Crude Fiber	6	8	6
Water	8	10	8
Nitrogen-free extract (carbohydrates)	60	64	54

[1] Based on Marsden and Martin, 1949 and Cline, 1936.

percentage of fat must be multiplied by 2.25 and added to the carbohydrate percentage. The factor 2.25 is used because fat liberates 2.25 times as much energy as does the same amount of carbohydrates. If the fat requirement is not met, the deficit must be made up from the carbohydrate percentage at the ratio of 1 fat to 2.25 carbohydrate. *Celtis reticulata* meets 38 per cent of the energy food requirements of breeders and 42 per cent of that for body maintenance. Any extra food above the amount required should not be disregarded because it is usually stored as fat.

In determination of the percentage of the mineral requirement only calcium and phosphorus were considered, although other minerals are also essential. Any excess mineral was disregarded because the value of excess minerals is questionable and in some cases detrimental (Marsden and Martin, 1949). *C. reticulata* meets 100 per cent of the calcium and phosphorus requirements for maintenance. It also meets the calcium requirement for breeding (2.2%) but does not meet the phosphorus requirement (0.7%). Only 2.52 per cent of *C. reticulata* consists of necessary minerals and 2.9 per cent is required; therefore, this food meets only 87 per cent of the mineral requirements for breeders. It contains more than enough calcium, but is deficient in phosphorus.

The percentages of protein, ash and energy requirement that the various foods meet are shown in Table 3.

The food of the young was evaluated in the same manner, but because their diet consists of only a few foods, the nutritional value of their foods is shown separately in Table 4.

TABLE 4.—FOOD OF YOUNG WILD TURKEYS COMPARED WITH NUTRITIONAL REQUIREMENTS

Food	% of diet met by Protein	Energy	Minerals
Celtis pallida	44	46	39
Fagara fruticosa	40	51	82
Lantana horrida	26	8	56
Prosopis juliflora	45	78	55
Insecta			
Beetles	169	0	66
Grasshoppers	189	8	71
Larvae (Lepidoptera)	111	24	57
Misc. and Spiders	205	0	75

It appears that most of the foods in Tables 3 and 4 are nutritionally deficient. However, these foods are usually eaten in various combinations. One food in the crop may be deficient in certain items and another food may make up the deficiency.

The next problem of application is to correlate the nutritional value of these foods with the amount eaten. Previously a food rank index (Beck, 1952) was developed to combine the volume, frequency, and specific gravity of a food into one number. The formula for this index was $x \cdot y \cdot z = R$ where: x is percentage volume times 100, y is percentage frequency, z is specific gravity, and

TABLE 3.—PERCENTAGE OF ADULT NUTRITIONAL REQUIREMENTS MET BY THE FOODS ANALYZED

Food	Percentages of breeder diet met			Percentages of maintenance diet met		
	Protein	Energy	Minerals	Protein	Energy	Minerals
Agrostis hiemalis	53	45	87	70	49	100
Brachiaria ciliatissima	82	75	59	108	77	100
Celtis pallida	63	42	28	82	46	62
Celtis reticulata	81	38	87	105	42	100
Cephalanthus sp.	77	68	83	101	71	93
Chloris (2 species)	108	48	71	141	52	100
Condalia spatulata	39	37	38	51	41	83
Cottonseed cake	241	26	83	315	32	100
Croton glandulosus	117	98	86	153	99	100
Croton lindheimeri	123	93	71	161	94	100
Croton texensis	113	107	51	148	107	100
Cyperus rotundus	100	72	91	131	75	100
Euphorbia sp.	103	71	90	135	74	100
Fagara fruticosa	57	46	80	75	50	87
Galactia grayii	106	92	86	139	93	100
Jatropha spatulata	57	100	86	74	101	100
Lantana horrida	37	7	41	48	13	87
Nicotiana sp.	121	68	94	158	71	100
Opuntia leptocaulis	16	1	15	22	8	33
Opuntia lindheimeri	47	55	87	61	59	100
Palafoxia texana	109	81	90	142	91	100
Panicum firmulum	71	72	87	93	74	100
Paspalum (3 species)	70	67	69	91	69	100
Pyrrhopappus multicaulis	104	84	77	135	85	100
Prosopis juliflora	64	70	40	83	73	87
Quercus virginianus	33	65	65	43	68	89
Senecio ampullaceous	105	106	96	137	106	100
Setaria (2 species)	78	72	27	102	75	59
Tricachne patens	112	62	87	146	65	100
Vaseyochloa multinervosa	77	69	90	101	72	100
Verbesina enceloides	137	83	92	179	85	100
Vicia sp.	97	66	88	126	68	100
Vitis mexicana	72	84	89	94	86	100
Xanthoxylum clava-herculis	77	121	89	100	121	100
Insecta						
Beetles	239	0	47	313	3	90
Grasshoppers	267	7	51	349	14	93
Larvae (Lepidoptera)	157	22	41	205	27	88
Misc. and Spiders	290	0	54	379	3	97
Snails (2 species)	58	0	92	75	0	100

R is the index number. (All percentages are expressed as decimals).

The nutritional factor, N, can be added to this basic formula: thus $x \cdot y \cdot z \cdot N = R$. N is determined by adding the percentages of the protein, energy, and mineral requirements met by the food (Table 3). For example:

Percentage requirements met by *Celtis reticulata*

	(Maintenance Diet)	(Breeder Diet)
Protein	1.05	0.81
Energy foods	0.42	0.38
Minerals	1.00	0.87
	2.47	2.06

The N value of this species for a maintenance diet is 2.47 and for a breeder diet is 2.06.

Table 5 shows the application of the formula to the food habits of wild turkeys in south Texas during the severe drouth of 1950–51. This table is a comparative index to the real importance of the foods because it combines value and utilization into one figure. Hence, a food such as *Opuntia leptocaulis* may be low in nutritional value but high in importance because of high utilization. Conversely, a food such as *Xanthoxylum* may rate higher in importance than in utilization because of high nutritional value. As yet, there is no standard for group food habits, so only the relative importance of the foods can be determined.

The outstanding winter foods of those analyzed were cottonseed cake, *Opuntia* and *Pyrrhopappus*. It is indeed fortunate that a food of high protein, such as cottonseed cake, was available. Otherwise, mortality from starvation during 1950–

TABLE 5.—A PARTIAL LIST OF WILD TURKEY FOODS SHOWING THEIR RELATIVE IMPORTANCE

Name	Winter	Spring [1]	Summer	Fall	Total
Cottonseed cake	66.73	6.60	6.11	63.49	142.93
Opuntia leptocaulis	8.18	....	....	1.21	9.39
Pyrrhopappus multicaulis	2.46	.03	....	....	2.49
Setaria (2 species)	.97	3.83	.33	.63	5.76
Snails (2 species)	.41	.26	.41	.15	1.23
Chloris (3 species)	.32	1.59	.10	.31	2.32
Lantana horrida	.10	3.47	.01	.19	3.77
Galactia grayii	.13	T	T	.45	0.58
Insecta	.11	92.29	7.97	17.11	117.48
Croton (3 species)	.07	.11	6.35	22.17	28.70
Nicotiana sp.	.04	1.34	....	....	1.38
Senecio ampullaceous	.01	.17	....	....	0.18
Paspalum (3 species)	T	20.34	.12	3.84	24.30
Brachiaria ciliatissima	T	7.13	6.11	....	13.24
Prosopis juliflora	....	4.13	28.20	3.46	35.79
Panicum firmulum	T	1.11	1.00	....	2.11
Celtis pallida	....	.20	51.50	2.02	53.72
Euphorbia sp.	....	.60	....	....	0.60
Vitis mexicana	....	.26	1.79	.61	2.66
Palafoxia texana	....	.01	.58	.91	1.50
Vaseyochloa multinervosa	....	T	....	2.62	2.62
Celtis reticulata	....	....	5.82	.27	6.09
Fagara fruiticosa	....	....	2.17	....	2.17
Xanthoxylum clava-herculis	....	....	1.62	1.00	2.62
Opuntia lindheimeri	....	....	.22	.30	0.52
Quercus virginianus	....	....	.19	28.01	28.20
Cyperus rotundus	....	....	.23	....	0.23
Tricachne patens	....	....	....	9.23	9.23
Condalia spatulata	....	....	....	1.02	1.02
Agrostis hiemalis	....	....	....	.36	0.36
Jatropha spatulata	....	....	....	.24	0.24
Verbesina enceloides	....	....	....	.08	0.08
	79.52	142.70	120.60	159.00	501.82

[1] Breeder standards; the other three seasons are maintenance standards.

51 might have been very high. Grass seeds and insects are the most important groups of foods in the spring, while trees and shrubs supply the more important summer foods. There were several important groups of foods in the fall.

There is a tendency to overlook the value of trace items and foods eaten in small amounts. The writers believe, however, that these seemingly unimportant foods may supply important amounts of necessary minerals.

According to the totals derived from seasonal indices, insects are the most important natural food with tree fruits and grass seeds close behind. Attention is again called to the highly important cottonseed cake which made up over one-fourth of the food index for 1950–51, a year of extreme drouth.

The N values of foods can also be applied to individual food habits. This is done by multiplying the weight of each food item in the crop by the nutritional value of that food. The figures representing each food are then added. There is a standard for comparison in this case. A turkey should eat about 0.03 pounds of feed per day for each pound of live weight (Cline, 1936). For a nine-pound hen, the amount is 123 grams. This figure is multiplied by the N value of a theoretically adequate food (3.00) to obtain the standard of 369.00. If the additive N value of the foods in the hen's crop does not equal the standard of 369, the hen's diet does not meet the requirements known to be adequate (Table 2). The fact that the diet is lower than this standard does not necessarily mean that the hen is starving. It means that the hen is not receiving a well balanced diet and that if the diet shortage continues, the bird will lose weight. Of course, in severe cases the turkey would starve. This type of comparison can give game managers a valuable hint as to the status of the food supply, as well as to the condition of the birds.

Table 6 gives a few examples of the application of nutritional values to the food habits of individual birds.

All but one of these specimens were below the theoretical standard. It appears obvious that turkeys A and D were not receiving enough food to meet their body requirements at the time they were collected.

DISCUSSION

This method of presenting food habits is more complicated and time-consuming than presently used methods, but is easily adapted to various animals. It gives a better picture of the real importance of a food to an animal because it takes into consideration the amount eaten, the number of individuals that ate the food, and the quality of the food.

TABLE 6.—THE FOODS EATEN BY SOME TURKEYS COMPARED TO A NUTRITIONALLY ADEQUATE FOOD

Turkey No.	Sex	Weight	N value of foods	Theoretical standard for the bird
A	Male	14 lbs.	97.10	573.0
B	Female	9 lbs.	126.83	367.8
C	Male	16 lbs.	334.40	654.0
D	Male	10 lbs.	66.10	409.5
E	Male	17.5 lbs.	908.30	714.0
F	Female	6.75 lbs.	199.80	276.0

Certain refinements are needed in the analysis. Other nutritional elements, such as vitamins, need to be considered as soon as the requirements can be definitely established and the foods analyzed.

Most of the foods taken by the wild turkey in south Texas during the drouth of 1950–51 appear to be adequate for a maintenance diet. The foods did, however, seem to be somewhat low in phosphorus for a breeder or poult diet. A phosphorus deficiency is in keeping with the phosphorus content of the soils of the King Ranch area.

The energy content of the foods was below the standards given for maintenance. The maintenance standards are set up for fattening pen-raised turkeys and are not the absolute minimum level needed for life. On the other hand, wild birds require more body fuel than do pen-raised birds. The seemingly low energy content of the foods is especially significant, in view of the fact that most of the turkeys collected had little or no fat stored in their bodies.

It seems quite probable that wild turkeys can continue to do well in south Texas on the natural foods present, except in years of extreme drouth.

The use of this method of food habits analysis has many possibilities for practical management from the standpoint of habitat improvement and supplemental feeding. Various food plantings could be developed and the spread of other plants encouraged. Balanced supplemental feeding to correct deficiencies or to prevent starvation could appreciably raise the number of animals available to the sportsman.

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UTILIZATION OF WINTER BROWSE ON WILDERNESS BIG GAME RANGE [1]

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During the late 1920's and early 1930's, signs of destructive use of big game winter range began to appear along the canyon of the Selway River of northern Idaho. The once-large mule deer herds of that isolated region were beginning to dwindle, and the formerly small elk herds had built up to numbers previously unrecorded. In the ensuing years, interested agencies carried on several studies of this problem. The most recent is Pittman-Robertson Project W-97-R of the Idaho Department of Fish and Game, the Selway Wilderness Game Study, which was begun in the fall of 1950, in cooperation with the United States Forest Service. In June of 1951, the Idaho Cooperative Wildlife Research Unit began active participation when the writer undertook some of the winter range studies. The objectives were investigations of composition of cover, stage of succession, current use, and availability of browse during winter. This paper is a part of a master's thesis entitled: A preliminary study of the Upper Selway River big game winter range with special reference to browse utilization.

[1] A contribution from the Idaho Cooperative Wildlife Research Unit, the University of Idaho, the Idaho Fish and Game Department, the U. S. Fish and Wildlife Service and Wildlife Management Institute cooperating. The author was formerly a research fellow in the Unit.

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The Area of Study

The area of study comprises the "upper Selway" portion of the Selway-Bitterroot Wilderness Area of the Bitterroot National Forest. Specifically, the 864,000-acre study area is the Selway River drainage above the mouth of Moose Creek, and the Moose Creek drainage, in Idaho County, Idaho. The boundaries of winter range fluctuate with the severity of the winter and are difficult to define precisely. The winter range is a section of the deep and steep-sided Selway River canyon approximately 50 miles long, with lateral extensions of 5 to 10 miles up the drainages of the major tributaries; this portion of the canyon drains from south to north through the center of the upper Selway basin.

The area is remote, separated from human settlements on all sides by deep ranks of other rugged mountains which contain a canyon system of rarely equalled length and depth. It is a part of the mountain mass drained by the Clearwater River system, described as a "maze of deep, very narrow, winding canyons with a succession of steep, high, rocky, narrow-crested ridges separating them" (Leiberg, 1900). Elevations range from 2,192 to more than 8,700 feet above sea level. Along the eastern boundary of the upper Selway drainage lies the Bitterroot Range, a narrow block rising nearly 2,000 feet above the crests of the Clearwater Mountains.

The soils are generally without a well-defined profile, and consist mainly of

coarse particles of granite. They lie mostly on steep slopes, and are well-drained. Litter and humus on most of the area is either lacking or very thin. Benches or bars or stream terraces of sand, gravel, and boulders with a thin layer of topsoil are found in the widenings along the main stream courses. Gullying is noticeable on the south-facing slopes where the vegetative cover is sparse or absent, and where elk and deer congregate during late winter months, but in general accelerated erosion has not been severe.

Year-round meteorological records for the area are not available, but it is apparent that "rain shadow" patterns exist. There are differences in annual precipitation in separate localities that have practically the same elevations. Most of the precipitation falls in the form of winter snow, but at the winter range elevations, the winters are comparatively warm, despite deep snows, and below-zero temperatures are usually of short duration. Summers are typically sunny, hot, and dry, with temperatures above 100°F not uncommon.

Prior to 1905, little or no private land was held in the Selway area, nor was any grazing of domestic livestock carried on, so far as is known. The Forest Homestead Act of 1906 provided that 160-acre homesteads could be made on national forest lands that were chiefly valuable for agriculture. The stream terraces and lower bench lands in the Selway Canyon were suspected of having agricultural possibilities, and in 1911 portions of the upper Selway area were opened for homestead entry. Some 15 or 20 applications were made, but only 12 made final proof (Parsell, 1950).

None of the ranch operators ever ran more than 60 head of cattle, 30 or 40 head being the usual maximum. Sheep raising was never attempted. The distance from market and the low productivity of the soils made these enterprises unsound. Dude ranching, or catering to hunting and fishing parties, is the source of income. Except for a relatively few head of horses and mules now used in the recreation business, and in Forest Service operations, livestock grazing has been eliminated.

Commercial logging has never been carried on; the management policy of technically designated wilderness areas does not permit it.

Fire is a major factor affecting the size of the big game populations of the upper Selway area. Presumably, large fires have occurred here periodically for as long as the climate has provided electrical storms and an annual dry season.

A large part of the area suffered extensive burns during the period 1750–1800. Most of the timber present in 1898 was second growth, ranging in age from 75 to 175 years (Leiberg, 1900).

Man has supplemented the effects of naturally-caused fires. Captains Lewis and Clark, although they never entered the Selway, passed through the Lochsa drainage, immediately to the north, in September of 1805 and again in June of 1806. Their journals mention large burned areas. The causes of the burns were not investigated, but it was noted that the Indians were in the habit of setting fire to the woods to bring fair weather for their journeys (Thwaites, 1905).

Some fires probably spread from Indian camp and signal fires, and some probably were purposely set to destroy the forest and encourage grass, especially in the alpine-fir type (summer range) along the main Indian trails. White prospectors were numerous in the whole Clearwater country during the period from 1860 to 1863, and again in the 1890's. They were notoriously care-

less with campfires, and were given to the deliberate starting of forest fires. In the early 1860's, prospectors along the Lochsa-Selway River divide reputedly set fires to destroy forest cover and thus facilitate their search for legendary lost gold mines (Leiberg, *op. cit.*). Referring to an area corresponding roughly to the upper Selway drainage, Leiberg estimated that 35 per cent had been practically denuded of forest during the gold-hunt period. Unfortunately, these estimates do not classify the burns according to life zones, elevations, or forest types. There is no estimate of the size of the areas in the shrub stage of succession immediately preceding the game population changes of the twentieth century.

Between 1910 and 1934 large fires removed the timber (sizes and ages unknown) from large areas of the upper Selway drainage, especially at winter range elevations. These recent fires, and the shrub stages which followed them, are closely associated with the present big game problem.

The vegetation of the upper Selway River drainage consists of the following zones described by Daubenmire (1952): (1) *Picea engelmanni-Abies lasiocarpa*[2]; (2) *Thuja plicata-Tsuga heterophylla*, in which the habitat types of *Thuja-Tsuga/Pachistima myrsinites* and *Thuja-Tsuga/Oplopanax horridum* are absent; (3) *Pseudotsuga taxifolia* var. *glauca;* (4) *Pinus ponderosa*, in which the *Pinus ponderosa / Purshia tridentata* habitat type is absent. The winter range lies mainly within the zones of ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga taxifolia* var. *glauca*). Areas of the cedar-hemlock (*Thuja plicata-Tsuga heterophylla*) zone occupy some of the broader parts of the canyon bottoms.

[2] Scientific names of plants are according to Davis (1952) unless otherwise indicated.

Big Game Populations

There are few records concerning abundance of elk (*Cervus canadensis canadensis*), mule deer (*Odocoileus hemionus hemionus*), and white tailed deer (*Odocoileus virginianus ochrourus*) prior to 1900. It is known that deer and elk were present in the Lochsa River drainage immediately to the north, and in the head of Lolo Creek of the Bitterroot River drainage just east of the Selway drainage in 1805 and 1806, when Lewis and Clark passed through those areas (Thwaites, 1905). Presumably these species were then present in the Selway area also, for the accounts of Indians and pioneers relate that mule deer were the major big game species, and elk were in the minority in the Selway country for at least a part of the nineteenth century (Case, 1938). White-tailed deer apparently were then, as they are now, a minor species from the standpoint of numbers.

After 1910, the elk population began to increase. Elk began to use what had been primarily mule deer winter range along the main Selway River, instead of only the higher slopes and the tributary canyons away from the river. During the period 1927–1936 the deer-elk ratio was reversed. The 1926 total deer population was estimated at 7,000 head, but in 1937 the estimate was only 2,620 mule deer and 555 white-tailed deer; the elk population, formerly numbering only a few hundred head, was estimated at 4,634 in 1937 (Maclay *et al.*, 1937). The deer-elk reversal coincided with winter range deterioration. As late as 1937 the greater part of the elk herds wintered in the northern parts of the winter range, although these areas were beginning to show signs of over-use as

early as 1931 (Maclay, *et al.*, 1937: U. S. Forest Service, *et al.*, 1937). At present, most of the elk winter farther south, upriver from those areas which were the first to show signs of deterioration.

Between 1910 and 1936, some factors which would tend to restrict the size of deer and elk herds were either decreased or removed. Fires resulted in large amounts of new browse forage on both summer and winter ranges; predator control activities were carried on; tooth and hide hunting ceased; and legitimate hunting was curtailed, although this probably never had been very heavy, due to the area's inaccessibility. In addition, large game preserves were established in and adjacent to the upper Selway area. Deer-elk competition for food supply during the critical winter periods became serious. Elk apparently were the more successful competitors.

BROWSE SURVEY METHODS

No attempt was made to sample vegetation by smaller plant communities. Browse utilization and cover were sampled on five key areas, selected from among 30 sites which carried the greatest numbers of elk during the winter of 1950–1951. At each of these five sites, five parallel randomly spaced transect lines were laid out, beginning at the river and proceeding 40 chains (one-half mile) up the lower slopes. A point or station, marked with a four-foot-long orange painted stake as an aid in locating the station in deep snow, was located at each two-chain interval along each transect line; each transect line thus contained 20 and each key area 100 stations. Shrubs or portions of them between the levels of two and seven feet were considered "available." The occurrence of the one available browse species nearest each stake was tallied to determine the relative browse range composition. On a test area, this expression of the relative abundance of available browse species was found to compare favorably with that obtained by using 50-foot line intercepts to sample crown coverage.

At each stake the area was mentally divided into quadrants by the transect line, and a line through the stake perpendicular to the transect line. A plastic tag was wired to the twig of the browse species nearest the stake in each quadrant, but only one twig of a single species was tagged at each stake. If a single species occupied the "nearest" position in more than one quadrant at a station, only one quadrant at that station could contain a tagged twig of that species. The remaining quadrants at that station contained tagged twigs of the different species which were "next nearest" the stake.

For those species on which the current year's growth was identifiable, the total length of all current annual growth beyond the tagged point of each twig was recorded. However, the current year's growth on some species was not recognizable; for such species only the total twig length beyond the tagged point could be measured. Thus, utilization on some species could be shown on the basis of annual growth, whereas use on certain other species could be expressed only as a fraction of total twig length.

It was arbitrarily assumed that the average snow depth on the winter range during the critical period would be about two feet. It was also assumed that elk would not be able to reach much of the browse that was more than seven feet above the ground. Therefore, only the browse between two and seven feet above the ground was considered available, and only the twigs within these limits were tagged and measured. Fall measurements were taken before elk and

deer in appreciable numbers were present on the winter range. Spring measurements were completed after the winter game concentrations had dispersed, and before the spring growth of the shrubs began. The difference between the fall and spring measurements represents the amount of utilization. Elk were by far the most numerous animals using the winter range; therefore, it is assumed that these figures represent elk utilization, for all practical management purposes.

Available browse cover was sampled by estimates on rectangular plots, 2′ x 8′ and 3′ x 16′. The former were found to be more efficient. These plots were also compared with 20-foot line intercepts of the Canfield (1941) method. Both methods were found to give reasonably comparable results, but the line intercepts were somewhat easier to use.

The line point method of Parker, *et al.* (1942), and line intercept methods were compared, using twenty-eight 50-foot line intercepts and fifty-one "points"; these were regularly spaced along parallel randomly spaced transect lines. Both methods indicated similar proportions of the major available browse species on the test site. The comparatively rapid line point method was selected for the extensive kind of sampling to be done on this study, and was used simultaneously with the sampling of utilization.

Linear measurement of twigs was used to sample browse utilization, after methods employed by Nelson (1930), Julander (1937), Aldous (1945) and Dasmann (1949; 1951).

The weight and weight estimate methods described by Carhart and Means (1941) were tested for sampling browse range composition and utilization, working with the plants in summer condition. It became obvious that there would not be time enough in the fall to do the clipping and weighing necessary to standardize the weight estimates, nor to sample by actual clipped weights of current annual growth. Nineteen identical plots were sampled by clipped weights and weight estimates, and by estimate of ground cover similar to methods used by Aldous (1944) and Morton (1950). With this rather small sample, and with leaves and fruit present on some species to add further error, these three methods gave largely dissimilar results. Other difficulties of methods involving clipping and weighing lay in the almost constantly wet condition of the browse during the rainy fall months. It seemed inadvisable to try to use green weights of wet clippings on the site. Facilities were inadequate for transporting and drying the necessary amounts of clipped browse samples.

Methods involving the "mental reconstruction" (*e.g.:* Aldous, 1944; Dasmann, 1951; Hormay, 1943) of the original lengths of browsed twigs were thought to be not practical, due to the growth forms of the browse species of this area; *i.e.*, vast differences are common in the lengths of twigs of similar diameter on a given species, and the lack of symmetry or compactness of available portions of the crown of these tall shrub species make it difficult to estimate the overall appearance of a bush or branch before it had been browsed upon. Similar objections hold for Grimm's (1939) method attempting before-and-after comparisons of paired halves of shrub crowns.

RESULTS AND DISCUSSION

Along the river breaks, or slopes adjacent to the Selway River, the available browse cover is generally dense (about 40 per cent ground cover) on north and east untimbered exposures.

On south and west slopes, the available browse cover is sparse, being as low as 5 per cent or less in many places. The herbaceous cover of these south and west slopes is equally poor, consisting mainly of cheatgrass (*Bromus tectorum*), dogbane (*Apocynum androsaemifolium*), and goatweed (*Hypericum perforatum*), with bracken fern (*Pteridium aquilinum* var. *lanuginosum*) at the bases of many of the steeper slopes.

The relative composition of available browse is summarized in Table 1. Scientific names of browse species will be found in this table.

Two major sources of error affected the sampling methods. Late in December, 1951, unusually heavy wet snow fell steadily for several days. This snow clung to the browse plants, bending and burying many of them. Subsequent snowstorms buried these plants even more deeply, and a heavy crust eventually formed on the snow. Regardless of its height, much browse was made unavailable during the greater part of the winter.

Of 2,000 twigs tagged in the fall, 675 were still buried, and therefore not measured in the early spring of 1952. Furthermore, some of the tagged twigs which had been unavailable all winter were released by the melting of the snow only a short time before they were discovered and measured in the spring. Consequently, many twigs which were recorded as unused were simply unavailable. An estimated 40 or 50 per cent of the tagged twigs were unavailable during part of the winter.

TABLE 1.—FREQUENCY OR OCCURRENCE OF AVAILABLE BROWSE SPECIES AT FIVE KEY AREAS Based Upon 100 Samples at Each Site

SPECIES	N. Fork Moose Cr.	N. Star Creek	Running Creek	Bad Luck Creek	Stewart Creek	Totals
Ceanothus sanguineus	8	32	37	22	43	142
Amelanchier florida	21	16	21	14	6	78
Physocarpus malvaceus	5	14	6	15	22	62
Symphoricarpos rivularis	5	5	14	11	15	50
Salix sp.	24	3	4	2	1	34
Philadelphus lewisi	5	3	2	13	5	28
Prunus emarginata	14	3	2	4	1	24
Rosa spp.	1	5	5	5	3	19
Holodiscus discolor	4	4	4	4	..	16
Acer glabrum	..	4	4	2	1	11
Pinus ponderosa	1	7	..	..	..	8
Prunus virginiana var. demissa	3	..	..	1	2	6
Cornus sericea	..	1	1	2	..	4
Ceanothus velutinus	3	..	..	..	..	3
Vaccinium membranaceum	..	..	..	3	..	3
Abies grandis	2	..	..	1	..	3
Lonicera spp.	..	2	..	..	1	3
Pseudotsuga taxifolia	2	..	..	..	..	2
Sorbus scopulina	..	..	..	1	..	1
Populus tremuloides	1	..	..	..	..	1
Rhamnus purshiana	1	..	..	..	..	1
Alnus tenuifolia	..	1	..	..	..	1
	100	100	100	100	100	500

All browse species were subject to snow-burial. The species of spreading habit and weak stems, such as redstem ceanothus, snowberry, and ninebark were more susceptible than taller species such as willow. Some browse forage is made unavailable every winter by snow, but these conditions were unusually severe during the winter of 1951–1952. Palatable plants which were unavailable during this particular winter nevertheless showed a generally hedged and severely overused condition, attesting to their availability during previous winters.

Reproduction of tree species within the winter range area is generally poor. Dense stands of young lodgepole pine cover some of the burned areas, but at higher elevations, mostly above the winter range. At lower elevations, there are small flats with stands of young Douglas fir and ponderosa pine whose major crown portions are now above the reach of browsing animals; the lower parts of these crowns are all "high-lined" by elk and deer. On most of the winter range, the young conifers have not fared so well. Conifer seedlings are infrequent, and are generally stunted, hedged, or killed back by browsing.

Redstem ceanothus is one of the two most abundant species on four of the five key areas, the exception being the North Fork of Moose Creek, where it ranked fourth in order of relative abundance. Probably there was more redstem ceanothus in the Moose Creek area 25 years ago. In 1937, it was estimated that up to 60 per cent of the browse had been completely killed out in that area (U. S. Forest Service *et al.*, 1937); presumably the highly palatable "redstem" was a substantial part of that 60 per cent.

Most of the redstem ceanothus, and much of the available serviceberry, willow, maple, cherry and other browse species preferred by the elk and deer are characterized by "broomy-looking" dead growth making up a good part of the individual crown spreads. This is an almost universal condition with the redstem ceanothus. The greater part of the dead twigs making up these dead crown portions do not terminate in dead buds, but end abruptly in a broken-off or bitten-off condition. On the other hand, the unpalatable ninebark, although it is one of the most abundant shrubs on the areas sampled, shows practically no signs of twig-loss and dead branches. Much of the willow is of small-tree size, 10 to 15 feet high, with main stems 3 or 4 inches in diameter. The edible parts of the crowns are above the reach of elk and deer, and the main stems are too stout to be bent down. However, even these large willow plants generally have available browse in the form of basal shoots. Serviceberry and maple also have portions of their crowns more than seven feet above the ground, but elk are able to force down the main stems of these species, and thus browse the high parts.

The presence of the plastic tag on a bush seemed to arouse elk curiosity. The tag on a species which ordinarily shows practically no use was frequently found chewed-on or pulled from the twig; often the twig was broken off at the tagged point, or the tagged twig was the only one on the entire plant which showed signs of having been nibbled on. This "curiosity factor" caused the occasional records of "100 per cent use" on species that are generally not eaten. Presumably this factor would affect both palatable and unpalatable species equally; *i.e.*, an elk would be as much attracted by a plastic tag on the unpalatable ninebark as on the palatable serviceberry. There was no way to determine which twigs were

unused because they were unavailable and which were unused because they were simply bypassed by the elk. Therefore, all unused twigs were disregarded, and mean utilization figures were computed only from twigs that were obviously used and available.

Utilization of the principal browse species for the winter of 1951–52 and 1952–53 is given in Table 2. The 1952–53 figures were secured from the Idaho Fish and Game Department.

The deep snows of the winter of 1951–52 caused elk to concentrate in the bottom and adjacent lower slopes of the Selway canyon, resulting in high utilization of the principal browse species. Also, the effect of the open winter of 1952–53 is seen in the comparatively light use of the same species. Although utilization figures were not available for Bad Luck Creek and Stewart Creek for the winter of 1952–53, observations indicated moderate use.

Abundant browse species utilized scarcely at all are: *Holodiscus discolor, Philadelphus lewisi, Physocarpus malvaceus,* and *Symphoricarpos rivularis.*

Although reliable quantitative data are lacking for the minor browse species, they are classed according to palatability and utilization by general observations on the area. Minor species are: *Rhamnus purshiana, Sorbus scopulina, Alnus tenuifolia, Cornus sericea* f. *stolonifera, Lonicera* spp., *Rosa* spp., *Ribes* spp., *Sambucus coerulea;* Seedlings and saplings of *Abies grandis, Pinus contorta* var. *latifolia, Pinus ponderosa, Pseudotsuga taxifolia.* Species low or nil in order of preference are: *Crataegus douglasi, Picea engelmanni, Rubus idaeus.*

SUMMARY

During the 1930's attention was focused on a big game problem in northern Idaho's upper Selway River drainage. In the years since 1910, there occurred a severe decline in the mule deer population, a great build-up of elk numbers, and the beginnings of destructive use of parts of the winter range, which eventually spread to the entire winter range. Just preceding or contemporary with these phenomena were vast forest fires resulting in large areas of new

TABLE 2.—UTILIZATION OF PRINCIPAL BROWSE SPECIES: WINTERS OF 1951–52 AND 1952–53

SPECIES	NORTH FORK MOOSE CREEK		NORTH STAR CREEK		RUNNING CREEK		BAD LUCK CREEN	STEWART CREEK
	'51–'52	'52–'53	'51–'52	'52–'53	'51–'52	'52–'53	'51–'52	'51–'52
Salix spp.*	73[1]	58	78	33	87	18	81	83
	44[2]	28	19	23	16	5	20	4
Amelanchier florida	81	17	81	5	90	11	82	77
	24	28	40	32	54	23	55	20
Prunus emarginata	71	7	67	0	86	0	85	..
	18	22	3	5	11	2	12	..
Ceanothus sanguineus	72	39	76	26	76	25	85	74
	22	13	19	33	37	23	20	35
*Ceanothus velutinus**	80	68	..	..	..	..	..	..
	12	4	..	..	..	..	..	..
Acer glabrum	..	12	85	19	87	13	85	85
	..	6	19	31	24	13	27	16
*Pseudotsuga taxifolia**	..	0	..	0	82	0	..	..
	..	2	..	2	10	3	..	..
Prunus virginiana var. demissa	..	41	72	..	..	..	82	70
	..	3	2	..	..	..	6	3

* Total twig length measured instead of annual growth.
[1] Percentage.
[2] Number of plants measured.

browse forage, plus restriction of legal hunting, decline of tooth and hide hunting, active predator control work, establishment of large wilderness game refuges, and the natural inaccessibility of the area for quick hunting trips by large numbers of modern sportsmen. One of several studies of the area's problems, the present one investigated browse forage conditions of the winter range during the winter of 1951–1952. Of the ten most abundant available shrub species, six were heavily used, while the other four were scarcely touched. This is presumed to be primarily elk utilization, since the combined mule and white-tailed deer population is estimated at less than one-third of the elk numbers on the area. Despite a decrease in elk numbers since the middle 1930's, it is apparent that the upper Selway winter range in its present condition is still inadequate for the numbers of elk using it during the winter of 1951–1952.

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WINTER BROWSE ON THE POCATELLO BIG GAME RANGE IN SOUTHEASTERN IDAHO,[1]

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The herds of mule deer and elk building up on the Pocatello Game Preserve and adjoining areas have been the concern of the Idaho Fish and Game Department, U. S. Forest Service, local sportsmen and ranchers. Work was initiated to determine the extent and degree of winter use of this area by big game; the condition and trend of range vegetation; the effects on the range vegetation of summer cattle use and yearlong elk and deer use; and to determine possible key plant species which might be used in the management of the big game herds. Field work covered a period from July 1, 1951 to May 15, 1952.

The study area is within the Pocatello Ranger District of the Caribou National Forest south and southeast of the City of Pocatello, and includes the entire Pocatello Game Preserve. The area comprises about 70,000 acres of which 39,043 are under U. S. Forest Service jurisdiction. It is enclosed on three sides by agricultural lands and on the west chiefly by lands administered by the Bureau of Indian Affairs.

The Bannock Range, in which the study area is located, has a general north-and-south trend and elevations vary from 4,461 feet at Pocatello to 8,500 at the summit of Scout Mountain. The topography varies from gently sloping valley bottoms in the agricultural lands along Marsh Creek and the Portneuf River on the East to the steep mountain slopes of the Bannock Range.

Limestones predominate throughout the area and quartzite outcroppings are found only on higher points. The soils are largely of limestone origin and the water flowing from this region is of considerable hardness (Lewis and Petersen, 1921).

About 1900, unregulated grazing of livestock began. The race for choice summer range began just as soon as the plants started to grow in the spring. As a result of over-grazing there was a rapid decline in the condition of the range vegetation.

In order to protect the water supply

[1] A contribution from The Idaho Cooperative Wildlife Research Unit. The University of Idaho, the Idaho Fish and Game Department, the U. S. Fish and Wildlife Service and the Wildlife Management Institute cooperating.

for the city of Pocatello, the original Pocatello Forest Preserve was created on September 15, 1903, of which Saunders (1915) made the following interesting observations:

> "Stream flow protection is the first object of the Service (Forest Service) on the area of the Pocatello City Watersheds. During the time that this area was part of the Indian Reservation, there was not much difficulty with streamflow protection, but when it was opened, the citizens received an object lesson in the effects of free grazing that led to the inclusion of the watershed in a forest and the prohibition of grazing. The protection of this area has been devoted to prevention of fire, prohibition of grazing, and replanting to forest. During the last five years, not five acres of this area has been burned. Control of grazing is more difficult because the boundaries are not fenced, but it may be stated that with the exclusion of stock, the forage has been completely replaced, forming a sight such as gladdened the eye of the first explorer, and incidentally a cover that prevents erosion and rapid runoff of water. The streams are almost always clear and the city of Pocatello has an exceptionally pure and palatable supply of water."

Mule deer were abundant fifty years ago. However, poaching and unrestricted hunting practically wiped out the herd. With the creation of the Pocatello Game Preserve in 1916, the herd was given some protection and by 1921 it was estimated that there were 100 mule deer on what is now the Pocatello division of the Caribou National Forest.

A closure was proclaimed by the State Game Warden in 1930 and was not opened until 1945, and then closed again until 1949. Since 1949, all deer hunting has been on a permit basis.

In 1916, seventeen elk were introduced into the area from Jackson Hole, Wyoming, and in 1917, eighteen more were released. From these 35 animals the present elk herd has developed. The aerial count of elk in 1932 showed 600 animals. The first elk hunt was held in 1933. Table 1 shows the elk numbers since 1916.

Both sheep and cattle were formerly grazed on portions of the Caribou Forest in the study area. In 1935, there were 13,970 cow-months and 38,000 sheep-months of use. By 1948, the use had been reduced to 8,000 cow-months and 3,280 sheep-months, a reduction of 17.4 per cent in cattle grazing, and since 1949, there have been no sheep allotments.

The renewable resources of timber, forage, and wildlife are managed on the multiple-use principle. Small logging operations are now in progress on the Walker Creek drainage. Cattle grazing is one of the principal sources of revenue for this Division of the Caribou National Forest. Such range improvements as water developments and salt grounds benefit both livestock and big game. In 1952, the grazing permits allowed 1,825 cattle for a period of June 1–October 15, or a total of 9,212 cow-months. Wildlife is an important resource. The legal kill of elk since the first permit hunt in 1933 has been 1,740 and the legal kill of deer has been at least 1,700 since 1943. In 1953, alone, 52 tons of elk and deer meat were harvested on this area. Since the Pocatello Game Preserve is so close to Pocatello and adjoining communities, permits to hunt are being increasingly sought by local residents. The Pocatello Division is in a critical watershed, from which the city of Pocatello uses nearly a million gallons of water daily. The agricultural economy of the surrounding communities is also dependent upon water for irrigation. A portion of Pocatello is built on the alluvial fan of four creeks coming down out of the preserve and is subject to flash floods unless vegetative cover is maintained on these drainages. Recreational uses of the area

other than hunting are ever on the increase.

VEGETATION TYPES

For purposes of cover mapping the vegetation was classified into eight fairly distinct types. They are described from the highest elevation downward.

CONIFEROUS FOREST TYPE — The small areas of spruce-fir zone are classed with the Douglas fir zone (Davis, 1952) since they are mingled in with the upper fringes of the latter. Douglas fir is the dominant tree species. The understory is made up largely of myrtle pachistima (*Pachistima myrsinites*), Oregon grape (*Berberis repens*), wild rose (*Rosa* spp.), western chokecherry (*Prunus virginiana demissa*), willow (*Salix* spp.), serviceberry (*Amelanchier alnifolia*), snowbrush ceanothus (*Ceanothus velutinus*), heartleaf arnica (*Arnica cordifolia*), elk sedge (*Carex geyeri*), pine grass (*Calamagrostis rubescens*), and blue wildrye (*Elymus glaucus*). Small areas dominated by aspen are dispersed throughout the type. The coniferous type including the aspen constitutes the principal summer range of both elk and mule deer. It is also much used as summer range by cattle.

Within the coniferous forest type are found a few areas of mountain meadow. These park-like meadows formerly supported dense growths of sedges and grasses. Years of over-grazing by livestock and elk have resulted in erosion and gullying, a lowered water table and a loss of much of the forage. Several less desirable plant species, such as mule's ears (*Wyethia amplexicaulis*), flannel mullein (*Verbascum thapsis*) and cheatgrass (*Bromus tectorum*), have increased.

ASPEN TYPE—Aspen covers much of

TABLE 1.—ELK PLANTED, COUNTED AND HARVESTED—POCATELLO HERD, 1916–1953

Year	No. Elk Planted	No. Elk Counted	Method of Count	No. of Permits	No. Elk Killed	Permit Success (Percent)
1916	17	...	.....	...	...	..
1917	18	...	.....	...	...	..
1932	..	600	Aerial	...	...	..
1933	..	...	.....	...	126	..
1936	..	...	.....	206	158	77
1937	..	759	Ground	100	90	90
1938	..	...	.....	100	75	75
1939	..	...	.....	200	138	69
1940	..	649	Aerial	200	140	70
1941	..	617	Aerial	100	65	65
1942	..	671	Aerial	100	75	75
1943	..	800	Estimate	100	85	85
1944	..	...	.....	100	83	83
1945	40 bull calves	815	Aerial	150	123	81
1946	..	643	Aerial	200*	69*	34*
1947	..	464	Aerial	150	127	85
1948	..	374	Aerial	...	No	Hunt
1949	..	475	Aerial	75	65	87
1950	..	417	Aerial	75	56	75
1951	..	319	Aerial	75	62	83
1952	..	564	Aerial	110	94	85
1953	..	574	Aerial	260	215	82

* 1946 hunt for bulls with four or more points; all other hunts either sex.

the high and more moist portions of the study area. This is probably a result of early fires in the Douglas fir zone. Typical understory plants include myrtle pachistima, Oregon grape, wild rose, western chokecherry, bigtooth maple (*Acer grandidentatum*), snowbrush ceanothus, serviceberry, heartleaf arnica, niggerhead (*Rudbeckia occidentalis*), elk sedge, blue wild-rye, and occasionally blue grasses (*Poa* spp.). This type is used by elk and mule deer during the spring, summer and fall.

MOUNTAIN MAHOGANY TYPE—Curlleaf mountain mahogany (*Cercocarpus ledifolius*), is usually found above the juniper type on steep, rocky slopes or ridge tops. It is usually found in scattered stands. The understory and associated species include: bitterbrush (*Purshia tridentata*), serviceberry, snowberry, (*Symphoricarpos* sp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), eriogonum (*Eriogonum* spp.), bluebunch wheatgrass (*Agropyron spicatum*) and Indian ricegrass (*Oryzopsis hymenoides*). On ridge tops with heavy past use, the ground cover may consist mostly of broom snakeweed (*Gutierrezia sarothrae*) and cheatgrass. The mountain mahogany type occupies somewhat less than 1,000 acres, but it represents an extremely important segment of the winter range—an importance out of proportion to the total acreage of winter range. Almost all stands of mountain mahogany have been "high lined" by deer. Individual plants take two forms. The large mature plants have large healthy vigorous crowns. The browse line occurs between six and seven feet in height and all new growth below that line has been removed annually. The other form is the hedged plant which has not been able to grow tall enough to escape the reach of deer. This type of mountain mahogany plant has all new growth removed above the snow line. Some plants in this form are dead; others are weakened and partially dead.

Reproduction of mountain mahogany is difficult to find. This is evidently not a recent development. The original timber survey in 1910 stated—"reproduction in the mahogany stands is very poor; juniper reproduction is better but in most instances not plentiful."

JUNIPER TYPE—The juniper type covers much more of the unit than does the mountain mahogany type, and is usually lower, altitudinally. The juniper type is found chiefly on south-facing slopes. Utah juniper (*Juniperus utahensis*) predominates, and scattered trees of the Rocky Mountain juniper (*Juniperus scopulorum*) occur on the more moist sites, especially near streams. Associated plants found in this type include bitterbrush, serviceberry, snowberry, arrowleaf balsamroot, bluebunch wheatgrass, and Indian ricegrass. In this type will also be found rabbitbrush, (*Chrysothamnus nauseosus* and *C. viscidiflorus*), big sagebrush (*Artemisia tridentata typica*), spineless horsebrush (*Tetradymia cansescens*), little sunflower (*Helianthella uniflora*), penstemon (*Penstemon* spp.), and giant wild-rye (*Elymus cinereus*). In areas which show heavy past use, broom snakeweed, cheatgrass, spineless horsebrush, and rabbitbrush are often abundant. The juniper type is used extensively by mule deer in winter. Usually, snow does not accumulate heavily in this type and the south-facing slopes furnish considerable forage as the snows melt during mild periods. The juniper itself furnishes considerable available browse even during deep snows.

SAGEBRUSH TYPE—This type makes up the largest single cover type of the study area. Big sagebrush is clearly the dominant plant, but the three-tipped

sagebrush (*Artemisia tridentata trifida*) is also common along with bitterbrush, rabbitbrush, spineless horsebrush, and eriogonum in varying amounts. Bluebunch wheatgrass is the most abundant grass. Bluestem wheatgrass (*Agropyron smithii*), Indian ricegrass, needle and thread grass (*Stipa comata*), giant wildrye and Sandberg bluegrass (*Poa secunda*) are also common. Important forbs include arrowleaf balsamroot, lupine (*Lupinus* spp.), hawks beard (*Crepis acuminata*), pale comandra (*Comandra pallida*), and death camas (*Zigadenus* spp.). Heavily grazed portions of this type show considerable amounts of broom snakeweed, cheatgrass, prickly pear cactus (*Opuntia* spp.), and gum weed (*Grindelia nana*). In the higher areas of this type such species occur as serviceberry, little sunflower, hawkweed (*Hieracium albertinum*), sticky geranium (*Geranium viscosissimum*), penstemon, snowberry, and leopard lily (*Fritillaria atropurpurea*). The lower portions of the sagebrush type are important as mule deer winter range.

BUNCHGRASS TYPE—The bunchgrass type is found from 5,000 feet to beyond 7,000 feet elevation. It occurs chiefly on ridges and on southwest-facing and west-facing windswept slopes near ridge tops. The principal dominants of the type are bluebunch wheatgrass, and Indian ricegrass. Common locally are needle and thread, giant wild-rye and june grass (*Koeleria cristata*). Over large acreages stunted plants of the black sage (*Artemisia tridentata nova*), is the only shrub. During the winter of 1951–52 this type was swept bare of snow much of the time by strong winds and provided the chief winter range of the Pocatello elk herd.

CULTIVATED LAND—This type lies along the Portneuf River from Pocatello to Inkom on the north and along Marsh Creek on the east. Several small farms extend up Mink Creek to the Forest boundary. The lower areas are usually irrigated with some higher benches dry farmed. Cereal grains and alfalfa are the principal crops. Elk depredations occur during the fall and early winter, but are usually of a minor nature.

METHODS

Intensive sampling was confined to exclosures and adjacent areas on Buck Creek and the East Fork of Mink Creek. Forty-acre sampling sites were established to include five-acre exclosures at each site. Composition and density of the vegetational cover was determined by the line-interception method (Can-

TABLE 2.—HUNTING PRESSURE SPECIAL HUNTS—POCATELLO GAME PRESERVE

Year	Permits		Hunter Success Permits Issued (Percent)	Success of Actual Hunters (Percent)
	No. Issued	No. Applicants		
	Elk			
1951	75	3,709	86.6	86.6
1952	110	4,573	85.5	87.6
1953	260	4,045	82.5	85.8
	Deer			
1951	400	750	72.9	84.1
1952	600	907	63.5	67.8
1953	650	998	62.2	71.5

field 1941). The interception of all perennial vegetation along a 100-foot cable was measured and recorded in feet and tenths of feet by species. Relative composition of the vegetation can be determined by totaling the measurements of each species along a sufficient number of lines. The amount of each species or forage class can then be expressed in terms of percentage of the ground cover and represents the relative amount of space completely covered with perennial vegetation. Shrubs were measured on the crown spread as intercepted by the vertical projection of the line. Single-stemmed forbs were measured on the stem diameter, whereas forbs of rosette form were measured on the intercept of the basal leaves. Grasses were measured at ground level and include only the intercept of living grass at that level.

Utilization of a browse plant is based upon the percentage of leaf and annual twig growth removed by browsing animals. Utilization was measured by a method described by Julander (1937). Percentages of annual growth utilized were determined by measuring twigs beyond a tagged point in the fall and then again in spring after the animals had left the winter range. A total of 1,331 twigs were tagged, representing 21,126 inches of annual growth on 17 species of browse plants. Selected shrubs were also photographed before and after use to compare over-all utilization.

ANALYSES OF DATA

Twenty-five line intercepts each 100 feet long were used to sample the vegetation on the East Fork of the Mink Creek 40-acre sampling site. The lines were located randomly and used to determine the percentage composition of the vegetation as well as the density (Table 3).

The principal shrub was bitterbrush which made up 21 per cent of the total perennial vegetation and 33 per cent of the total shrub density. Snowberry ranked second with a density of 13.1 per cent and big sagebrush third with 6.4 per cent density.

TABLE 3.—DENSITY AND COMPOSITION BY FORAGE CLASSES OF THE VEGETATION ON EAST FORK OF MINK CREEK 40-ACRE SAMPLING SITE BASED ON TWENTY-FIVE 100-FOOT TRANSECTS

Forage Class	Density in Percent of Cover	Percent of Total Vegetation
Shrubs	43.6	64.0
Forbs	21.2	31.2
Grasses	3.3	4.8
Total:	68.1	100.0

The Buck Creek 40-acre sampling site was divided into sagebrush, juniper, and aspen vegetation types, occupying 27 acres, 7 acres and 6 acres respectively. The three shrubs, sagebrush, snowberry and bitterbrush made up four-fifths of the total shrub density (Table 4).

TABLE 4.—DENSITY AND COMPOSITION BY FORAGE CLASSES IN THE SAGEBRUSH TYPE OF THE VEGETATION ON BUCK CREEK 40-ACRE SAMPLING SITE BASED UPON SEVENTEEN 100-FOOT TRANSECTS

Forage Class	Density in Percent of Cover	Percent of Total Vegetation
Shrubs	37.8	75.6
Forbs	10.1	20.2
Grasses	2.1	4.2
Total:	50.0	100.0

The sagebrush type on Buck Creek was also sampled with 61 clipped plots, each 1′ x 8′ laid out at random. The annual growth was clipped from all shrubs and all perennial grasses. A yield of 370

pounds of air-dried forage per acre remained after the cattle grazing season. Forbs were not clipped since they were dried and badly shattered at the time of sampling. The density and composition of the three most important shrubs on Buck Creek by the line intercept method totaled 81.8 per cent, and 78.7 per cent by weight.

IMPORTANT BROWSE SPECIES

BITTERBRUSH—This species is widely recognized as an important browse plant for both livestock and mule deer (Hormay, 1943; Stoddart and Rasmussen, 1945; Blaisdell, 1950). On the Pocatello winter range, bitterbrush is one of the two browse plants most heavily used (Table 5). Another indication of the importance of bitterbrush was seen from snow trailing of mule deer on their winter range. Out of a total of 358 feeding stops during January, February, and March, 141 or 39.6 per cent were on bitterbrush. The heaviest use on bitterbrush was early in the winter.

Reproduction of bitterbrush on the Pocatello winter range has been only fair in recent years. A large scale sample of bitterbrush reproduction was not taken. However, in a sample of 50 plots each 3′ x 3′, only four plots contained any seedlings. Rodents may be both beneficial and detrimental to bitterbrush (Hormay, 1943). Chipmunks and mice are known to eat large quantities of ripening bitterbrush seed in summer and fall. This loss, however, may be more than compensated for by the seed caching activities of these rodents. A large number of seed caches were observed germinating on the Pocatello range in the spring of 1952. Many of these seedlings will survive if favorable moisture conditions prevail during the summer months.

Rodents did some girdling of mature bitterbrush plants during the winter of 1951–52. The damage occurred under the snow.

BIG SAGEBRUSH—Big sagebrush is an important winter food for mule deer on

TABLE 5.—SUMMARY OF UTILIZATION ON TAGGED TWIGS AT BUCK CREEK AND EAST FORK OF MINK CREEK BASED ON 1,331 TAGGED TWIGS ON 67 TRANSECTS

SPECIES	No. Twigs Tagged	No. Twigs Browsed	Percent Tagged Twigs Browsed	Percent Use On Browsed Twigs	Inches Annual Growth Tagged Twigs	Inches Annual Growth Taken	Percent Over-all Use
Purshia tridentata	406	167	41.0	58.7	6,672.5	1,799.0	26.9
Amelanchier alnifolia	213	9	4.2	51.2	2,041.0	34.0	1.6
Cercocarpus ledifolius	155	141	91.0	82.3	2,934.0	2,196.0	74.9
Prunus virginiana demissa	127	8	6.3	59.4	1,283.5	59.5	4.6
Populus tremuloides	71	1	1.4	66.6	1,788.5	8.0	0.4
Artemisia tridentata	63	2	3.2	37.0	1,381.0	22.0	1.6
Rosa spp.	54	6	11.0	49.1	535.0	34.0	6.4
Chrysothamnus viscidiflorus	40	0	0.0	0.0	1,355.0	0.0	0.0
Symphoricarpos sp.	37	0	0.0	0.0	447.0	0.0	0.0
Cornus sericea stolonifera	35	0	0.0	0.0	507.0	0.0	0.0
Pseudotsuga taxifolia	30	0	0.0	0.0	503.0	0.0	0.0
Ceanothus velutinus	25	1	4.0	53.0	293.0	9.0	3.1
Pachistima myrsinities	20	5	25.0	48.8	207.0	39.0	18.8
Acer glabrum	20	0	0.0	0.0	213.0	0.0	0.0
Salix spp.	20	0	0.0	0.0	855.0	0.0	0.0
Betula occidentalis	5	1	20.0	28.6	78.0	8.0	10.2
Crataegus rivularis	5	0	0.0	0.0	33.0	0.0	0.0
TOTAL:	1,331	341					

the Pocatello winter range. It is more heavily taken in middle and late winter after the more highly preferred species have had fairly heavy use. General use was noted in January when bitterbrush and mountain mahogany had already shown heavy use. Snow trailing showed that out of 358 feeding stops, 102, or 28.5 per cent were for use of big sagebrush. Of 29 stomachs from dead deer found in late winter, 27 contained sagebrush in varying amounts. Big sagebrush is important on this winter range because it is found in all three winter range types, it is quite palatable, easily available and receives little use by cattle. In addition, reproduction of big sagebrush is no problem, seedlings and young plants are abundant throughout the sagebrush type.

CURLLEAF MOUNTAIN MAHOGANY—Mountain mahogany is an important shrub on the Pocatello winter range. It has little palatability for domestic livestock and is listed as an undesirable range plant by Heidenreich and Clark (1946), from the standpoint of domestic stock. It is however, an important food for mule deer. Mountain mahogany ranks first in preference during December and January. As seen in Table 5, the over-all use was 75 per cent for the winter of 1951–52. Little is known concerning the withstandability of the species to heavy and continued browsing.

On the Pocatello winter range only two classes of mountain mahogany plants can be found. These are the mature tree-like plants which are browse-lined to a height of about seven feet and the smaller plants that are annually eaten down to the snow line. Most of the utilization on the smaller plants occurs early in the winter. Some of the largest groves of mahogany occur at about 6,600 feet elevation, which is higher than most of the mule deer winter range. However, from forty to eighty deer were observed in these groves on several occasions throughout the winter.

Seedlings and young plants of mountain mahogany are difficult to find. This was noted in the original timber survey and is equally true today. Little is known of the ecology of this valuable browse plant especially in regard to establishment and survival of seedlings.

UTAH JUNIPER—The last important browse plant to merit individual discussion is Utah juniper, locally known as cedar. This plant is of little value to cattle but is of importance as winter browse to mule deer. Deer frequent this cover type throughout the winter and were observed feeding on juniper. No general "high lining" of juniper occurs but individual trees are frequently found with nearly all available branches heavily used. Stoddart and Smith (1943), suggest that this apparent difference in palatability may be due to the different mineral or salt content of plants caused by soil variations. Utah juniper was the second most common species found in the 29 dead deer. It occurred in 17 deer and in considerable quantities.

LIVESTOCK—BIG GAME COMPETITION

General observations were made on the degree of competition between cattle and elk, cattle and deer, and elk and deer. Observations were made on the cover types used, general feeding habits, and preferred food plants of cattle, elk and deer.

Cattle and elk have the same general feeding habits during the summer. The coniferous forest and aspen types were much used by both cattle and elk, but competition between the two species was probably minor because of the relatively large areas available for summer use. Although cattle and elk were fre-

quently seen feeding in the same aspen groves, the elk tended to use the higher and steeper slopes. Winter ranges used by elk and summer ranges used by cattle did not overlap seriously. In late November and early December the majority of elk migrated to the high open ridges and remained there most of the winter. These slopes and ridges in the bunchgrass type showed little summer use by cattle because of a lack of nearby water. Strong winds kept these areas blown free of snow much of the winter. These bunchgrasses made up a major portion of the diet of the elk during the winter of 1951–52.

Cattle and deer have different forage preferences in both winter and summer and compete directly for only a few important plants. The chief species used jointly by both cattle and deer is bitterbrush. Cattle were seen to feed on new growth of bitterbrush to a considerable extent during late August and early September. Much of this use, however, was concentrated on a relatively narrow strip on the lower slopes along the stream bottoms. Winter use of bitterbrush by deer was chiefly higher and nearer the ridges where snow did not accumulate so heavily. The competition was minimized in a winter of heavy snow. In a more open winter, deer might well browse bitterbrush plants already browsed by cattle. However, many important plants in the fall and winter diet of mule deer are almost untouched by cattle. These include big sagebrush, curlleaf mountain mahogany, Utah juniper, myrtle-pachistima, Oregon grape, snowbrush ceanothus, eriogonum, prickly pear cactus, and arrowleaf balsamroot. Stomach contents from mule deer killed November 11–15, 1951 indicated a high percentage of food to be pachistima and Oregon grape. Observations of December 14, 1951 show deer digging through a foot of snow to feed on pachistima.

On the Pocatello Game Preserve competition between present numbers of deer and elk is not serious. There is however, a direct competition between deer and elk for new growth of grasses and balsamroot in the early spring. Both species avidly seek out the first tender shoots of grass and arrowleaf balsamroot and crop them closely to the ground for a period of three to four weeks. Use of these plants is severe only on the lower south-facing slopes where new growth first appears.

The degree of competition varies with different ranges and each range must be considered separately. Vegetative composition, season of use, class of livestock, species of big game and topography and soils all must be evaluated in any thorough study of competition for forage on any given range.

CONCLUSIONS

In general, the winter range of the Pocatello deer and elk herds is in good condition. A conservative level of cattle grazing and the elimination of sheep permits by the U. S. Forest Service has contributed toward a satisfactory management of the range. The annual deer and elk harvest set by the Fish and Game Department's annual counts and spring range examination have established desirable big game management practices. During the years 1949–1951 only 637 deer were harvested out of 1100 permits.[2] This low percentage (58) permitted a buildup of the deer herd to a size well above the optimum for the

[2] In the hunting seasons of 1952 and 1953, 64 and 62 per cent of permittees killed deer,—omitting 1950 when no special hunt fee was required and only 41 per cent of the permittees killed deer, the four-year average of harvested deer to permits issued was 65 per cent.

winter range. Over-use on the better browse plants during the winter of 1951–52 indicated that if the deer herd were maintained at its present level the range would almost certainly deteriorate. Delay in reduction of deer on over-populated ranges means ultimate shrinkage of both the herd and the range.

Bitterbrush and mountain mahogany are the two key plant species for deer management on the area. If only 60 per cent of the annual growth on these two plants is taken, no other plant species is likely to be over-utilized. However, the winter of 1951–52 has clearly demonstrated that over-use of these two plants is accompanied by over-use of the range vegetation in general.

Direct competition exists between elk and deer for certain low browse species in the late fall. Elk and deer also compete directly for new growth of grasses and balsamroot in the spring. Under heavier use or with range depletion, competition between any two classes of animals could become serious.

SUMMARY

1. An investigation of browse plant utilization on the Pocatello winter big game range was carried on from July 1, 1951 to May 15, 1952. The 70,000-acre study area lies south and east of Pocatello in Bannock County, Idaho, and includes both Caribou National Forest and private lands.

2. Eight cover types are recognized: Coniferous forest, mountain meadow, aspen, mountain mahogany, juniper, sagebrush, bunchgrass and cultivated land.

3. Intensive work on plant composition and browse utilization was centered around two exclosures on Buck Creek and on the East Fork of Mink Creek in 1949. General observations on browse condition and utilization were made on most of the winter range.

4. Forage inventory was made by the line intercept method. The East Fork of Mink Creek study area showed that the perennial cover was 64 per cent shrubs, 31 per cent forbs and 5 per cent grasses. Bitterbrush was the principal shrub making up about one-half the shrub cover. The Buck Creek site was divided into aspen, juniper, and sagebrush cover types. In the sagebrush type, shrubs accounted for 76 per cent of the perennial cover, forbs 20 per cent and grasses 4 per cent. Big sagebrush made up a third of all the shrub cover.

5. Clippings on 61 one-by-eight-foot plots showed that big sagebrush, snowberry and bitterbrush made up 79 per cent of the browse by weight. The line intercept method gave 81 per cent of the total browse by the same three species.

6. Utilization was measured by the tagged twig method. Mountain mahogany showed 82 per cent, bitterbrush 59 per cent and big sagebrush 27 per cent utilization. Additional forage preferences were determined by snow trailing and from stomach contents of dead deer found on the winter range.

7. The four most important plants for winter mule deer management on the Pocatello Game Preserve are bitterbrush, mountain mahogany, big sagebrush and juniper. Deer preference, plant abundance and winter availability were the criteria used in evaluating these plants.

8. Elk wintered generally on high windswept ridges. Therefore the cured bunchgrasses were the most important plants for elk in the winter of 1951–52.

9. Direct competition between cattle and elk, cattle and deer and elk and deer was noted but is not serious under the present degree of stocking. Under heavier

use, the competition between any two classes of animals could become serious.

10. The winter range of the Pocatello big game herds is generally in good condition. The deer herd is too large for moderately severe winters such as experienced in 1951–52.

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EVIDENCE OF INFECTIOUS DISEASES AND PARASITES IN A PEAK POPULATION OF BLACK-TAILED JACK RABBITS IN NEVADA [1]

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This report concerns evidence of infectious agents or parasites observed in the black-tailed jack rabbit, (*Lepus californicus deserticola*) in northern Nevada in 1951 and 1952. The animals had been known to be near peak abundance in the previous three to four years in many areas in the vicinity of Battle Mountain and Winnemucca where many ranchers had reported them in increasing pest proportions. Localized die-offs reported late in the summer of 1951 afforded opportunities to investigate factors of environmental pressure and to determine whether or not such factors were actually responsible for the reported decimation.

[1] Read (and abstract published) before Section X, Parasitology, XIV International Zoological Congress, Copenhagen, August 10, 1953.

FIELD OBSERVATIONS

Three visits were made in September, October, and November in 1951, and in 1952 an observer was stationed in the area continuously from mid-June to mid-August. Most observations were made on large stock-ranches in an arid, sagebrush type of environment. Only a small part of each was cultivated along streams or spring seepages. The hares tended to converge in excessive numbers on cultivated hay lands as the summer advanced. Evidence of heavy damage along the edges of such fields was corroborated by actual counts of animals in evenings and early mornings in these situations. Fifty or more hares could often be seen in a single hayfield toward evening, while after dark, a drive around such a field would commonly reveal from five to ten hares continuously being passed in the spotlight of the moving car. Vigorous shooting, trapping, poisoning and fencing were ineffective in reducing invasion of fields by these hordes of hares.

Cycles of abundance and scarcity of animals in the past are well known to the local ranchers. They have no convincing theory as to the cause, though many persons have claimed that "boils" and "blackheads" are commonly seen on hares before or during die-offs.

In September 1951, it was learned that sick and recently dead animals had been observed in mid-July on several isolated ranches, there frequently being no evidence of decimation on adjoining or intervening ranches on the same drainage. At this time (July), sick and dying hares were seen by residents in midday and these lethargic animals could be approached and killed with a blow. Mummified carcasses still remained in September, but no freshly dead animals were found for laboratory study. Hares in apparently poor condition were still common in several such areas during the September visit. Whether these were surviving animals, or hares newly invading the area was not ascertained.

In 1951, old carcasses and freshly shot hares were collected for study. Blood samples were drawn where practicable from many of the latter. Most of the hares shot in the field were placed in bags for overnight cooling and recovery of ectoparasites. In a few instances, brains were removed and stored in buffered glycerin in an ice chest until the collectors returned to the laboratory. Ticks and bot larvae from each locality were pooled in pill boxes and stored in moist containers. No fleas were found.

In 1952, similar conditions of localized decimation were not encountered, but observers noted that in some areas as the summer advanced excessive bot infestations obviously caused death of some hares by blinding and debilitation. These observations are discussed below. The preceding exceptionally hard winter followed by spring floods, which caused losses of deer and stock in the region, also adversely affected the hare population in some areas, but they returned in excessive numbers in many places by late summer.

LABORATORY INVESTIGATIONS

MODIFIED ASCOLI TESTS. Though many dried mummified carcasses were sampled from bone and skin remnants in 1951, no positive tests for *Bacterium tularense* and *Pasteurella pestis* were obtained by the methods found successful with experimentally dried tissues by Larson *et al.* (1950–1951). However, all internal tissues of dried carcasses collected in the field had been devoured by various scavenging agents, possibly precluding

adequate tests such as were attained in the experimental studies.

It was observed on the second trip in October 1951 that animals shot a month earlier had become mummified under desert conditions, while the remains of scattered carcasses from the July decimation were difficult to find during the later visit.

In 1952, no Ascoli tests were attempted since the only carcasses found were in areas of heavy bot infestation.

SEROLOGY. Not one of 342 hare sera tested in 1951 or of 134 tested in 1952 showed agglutinins against *B. tularense*, although sera from three hares collected in 1951 from one ranch showed significant titers against *Brucella*. Some of the 1951 samples were from hares shot in localized areas in which a die-off had occurred two months earlier. Complement-fixing antibodies in significant titer for Rocky Mountain spotted fever, (RMsf), were demonstrated in 8 of 127 samples in 1951, and in 27 of 133 in 1952. Since tests of rabbit sera are notoriously difficult to interpret in the complement-fixation test (DeBoer and Cox, 1947), these results represent a conservative estimate of positive results. There was a number of other serum samples that were suspected but discounted as positive for various technical reasons.

In addition, a laboratory rabbit on which a group of *Otobius lagophilus* ticks from these wild hares had been fed also developed a high complement-fixing titer for spotted fever antigen.

NEUTRALIZATION TESTS. The presence of neutralizing antibodies against western equine encephalitis (WEE virus) and Colorado tick fever virus was demonstrated in some sera from hares, employing appropriate standardized mouse tests. Twenty-eight of 202 samples collected in 1951 and 10 of 73 collected in 1952 gave positive reactions against WEE Virus and 6 of 24 obtained in 1952 gave positive tests for Colorado tick fever. Of the first, 16 of the 28 positives were from one ranch on which sick horses as well as one serologically proved case of human encephalitis had been reported earlier.

In comparing results of neutralization and complement-fixation tests for WEE antibodies in hare sera collected in 1951, there were 3 of 31 reactors that showed neutralization of virus but no fixation of complement, and 6 others in which fixation was nonspecific; conversely there were 4 that showed positive fixation in dilutions of 1:12 to 1:32 in which no neutralizing antibodies were demonstrated. Seven had positive neutralizing titers against WEE virus as high as 1000 to 4200 mouse LD_{50}.

The tests were carefully controlled to eliminate non-specific effects and therefore the reactions probably indicate prior infections with WEE virus. Some of the apparently discrepant results between complement-fixation and neutralization tests may be explained by known differences in the time of development and duration of complement-fixation and neutralizing antibodies.

A selected series of the hare sera obtained in 1952 that gave positive complement-fixation reactions against spotted fever antigen was subjected to toxin-neutralization test in mice by Dr. E. J. Bell. (For methods see Bell and Pickens, 1953). Four of eight were also positive by this test in serum dilutions between 1:8 and 1:64; the other four gave no neutralization. Of five others which were negative in complement-fixation tests, two gave positive neutralization titers of 1:16 and 1:32, respectively.

RECOVERY AND IDENTIFICATION OF DISEASE AGENTS. *B. tularense* isolates were

recovered from 3 of 14 lots of *Dermacentor parumapertus* in 1951, and from 2 of 24 lots in 1952, (all of which had been collected from serologically negative hares), by injection of saline suspensions of ticks intraperitoneally and subcutaneously into paired guinea pigs. These strains were confirmed by agglutination tests, and were also found to be highly virulent, killing domestic rabbits, guinea pigs, and white mice in approximately the same dilutions.

One and two of the respective 1951 and 1952 lots of ticks also provided rickettsial strains closely related to if not identical with *Rickettsia rickettsii*, but of lower pathogenicity for guinea pigs than the fatal isolates usually obtained from *D. andersoni* ticks. For example, two engorged nymphs and one adult *D. parumapertus* of one lot were injected intraperitoneally into a guinea pig which developed scrotal swelling on the sixth and seventh days but remained afebrile. When this animal was sacrificed, slight enlargement of the spleen and mild injection of the tunicas were noted. The responsible agent was carried by spleen transfer from sacrificed animals through four, paired guinea pig passages with only two test animals showing temperatures over 40° C; the majority developed one or two days of low fever and one had none at all. On the other hand, only one failed to develop a scrotal reaction. When recovered animals were challenged with a virulent strain of *R. rickettsii*, the resulting reactions varied, there being complete, partial, or no immunity. Sera of these passage animals were all negative for complement-fixing antibodies to spotted fever antigen.

Of six animals vaccinated with Rocky Mountain Laboratory tick-type vaccine, only two were protected against challenge with the agent isolated from *D. parumapertus*, although four of six others were fully protected and the other two were partially so against fully virulent laboratory passage Rocky Mountain spotted fever. Some serological divergence to be reported elsewhere also suggests that the *parumapertus* agent is not completely identical with *R. rickettsii*.

Attempted isolation of WEE virus and RMsf rickettsiae by injection of mice and guinea pigs, respectively, with 81 and 26 glycerin-preserved brains of hares shot in 1951 was unsuccessful.

Baby mice were not employed in 1951 to test for presence of Colorado tick fever in tick suspensions, but in 1952 three isolates of this virus were recovered from *D. parumapertus* and one from the soft tick, *Otobius lagophilus*. Identity of these viruses was proven by injection of Seitz filtrates into mice, and by mouse neutralization tests with known antiserums.

PARASITISM BY RABBIT BOTS

Cuterebra bot larvae are well known parasites that have often been observed by us in subcutaneous cystic cavities in hares and rabbits collected in the field. Seldom has more than one been seen in an animal and there has been no apparent effect on the general health of the host. Consequently, multiple infestations of these large bots in hares on certain Nevada ranches in 1952, with resultant illness and some mortality, proved to be a surprising observation. Abundance of hares undoubtedly provided unusual exposure and opportunity for these parasites to multiply in local areas. There was an obvious predilection by the bots for the subcutaneous tissues about the heads of the hosts. Multiple infestations were not unusual. In some cases, as illustrated in Fig. 1, one or both eyes of the victims were closed by

FIG. 1. Two heads of Nevada black-tailed jack rabbits, partially skinned to show heavy parasitism by *Cuterebra* bot larvae, including one early instar. Two-thirds of the engorged tick in the eye socket of the head on right not visible, causing compression of the eyeball.

adjacent bot larvae. Weakened and blinded hares, in obvious distress, behaved abnormally and wandered about during midday. In mid-August when the maximum infestations were observed, all larval instars of these parasites could be found, including young larvae migrating under the skin causing inflammation and edema, and formation of cystic cavities with sinuses through the host's skin to which the respiratory spiracles of the parasites were apposed. Pus and sero-sanguineous fluids were often observed in these bot cavities, and older, healing, lesions were commonly seen after escape of mature larvae. In a few cases, disintegrating larvae were seen under the skins of the animals in healing lesions.

Mature bots escaping from shot hares were often found in bags which were used to recover ticks. Some of these were retained for pupation. One fly emerged in three months, and three others in eight to nine months. These represented two species, namely *Cuterebra ruficrus* and *C. jellisoni* (*var.*?)

No attempt was made to test these bot larvae for presence of infectious agents. The observer, however, was able to correlate obvious illness in hares with bot infestations at the time of shooting. Twenty-seven hares which were considered normal were shot on three ranches and of these, 18 were uninfested and nine had only one to two bots each. Thirty hares which were considered abnormal were shot. All were parasitized by bots and the majority had multiple infestations; four hares had one bot each, twelve had two, four had three, six had four, two had five, and one each had the

astonishing numbers of six and seven large bot larvae respectively, all located under the skin of the head. Heads of such hares were often very misshapen in consequence and the animals were obviously in great distress.

DISCUSSION

Two questions are raised by the above observations: What bearing does this evidence have (1) on the cause of observed periodic decimation of black-tailed jack rabbit populations and (2) on human disease in the area? The answers have not been forthcoming from the present field and laboratory studies.

It was obvious that hares had decreased in local situations due to a variety of stresses. For example, *Cuterebra* bots were excessive in numbers in 1952, undoubtedly causing some deaths and giving rise to repeated local reports of the presence of "boils" and "blackheads." But there was also mortality which could not be attributed to these parasites, since hares shot in the areas of decimation in 1951 showed no such excessive parasitism. Again, although some ticks collected during both years were obviously carrying virulent *B. tularense*, this organism did not appear to be a cause of widespread decimation. Avirulent strains are known to occur in nature (Davis, Philip and Parker, 1934, Bell and Green, 1939), but those recovered from ticks in this study were shown to be highly virulent.

Other evidence in July 1951 of the presence of tularemia in the Battle Mountain area included a patient of C. C. Hyde, M.D. A ranch worker developed a severe infection after being bitten on the neck by a large horsefly. The ranch hand identified the horsefly, which he killed while it was biting, by description and later comparison of exhibited, pinned specimens as the locally common, large black horsefly, *Tabanus punctifer*. It appears likely that this fly had contaminated mouthparts from previously biting an infected hare. A dog on another ranch 35 miles distant developed a severe illness which was diagnosed by G. T. Woodward, D.V.M., as tularemia. The sera of both the man and dog had high agglutination titers against *B. tularense*. The dog had been killing hares, particularly sick ones. A coyote shot in another area also had a high titer for *B. tularense*, possibly due to eating infected hares.

Other human diseases of interest included a number of clinically diagnosed cases of Colorado tick fever presenting histories of tick bite in the Elko-Battle Mountain areas, from nine of which strains of virus were isolated in 1952. Eight local human cases of encephalitis, confirmed by mouse-neutralization tests, also occurred during the two years. Clinical cases in horses were also reported each year by various local ranchers most of whom vaccinate only the most valuable of their animals, thus having a large reservoir of susceptible animals.

Since none of the sera from hares contained tularemia agglutinins, it is suggested that all animals succumb when infected with *B. tularense*. This has been the interpretation for the observation that cottontail rabbits (*Sylvilagus*) do not possess antibodies in nature (Bell and Chalgren, 1943). Snowshoe hares (*L. americanus*) on the other hand develop antibodies (Bell and Green, 1939), indicating that some of them recover from tularemia infections. The susceptibility of six black-tailed jack rabbits imported from Kansas was tested to determine if they were highly susceptible to infection with *B. tularense* and if survivors developed agglutinins. Each of 4 were injected with a suspension of 10^6

or more organisms (as determined by titrations in mice) with a proved virulent strain and all died: two of these yielded pure cultures of *B. tularense*; one developed an agglutination titer of 1:40 before death on the sixth day after injection. Neither of two other Kansas hares injected with only about 100 organisms each, became ill or developed any detectable antibodies after 34 days.

The susceptibility of hares to WEE virus administered subcutaneously and by cisternal puncture was tested. It was found that hares were resistant to 10^8 mouse LD_{50} injected subcutaneously and to 10^3 LD_{50} by the intrathecal route, but succumbed to 10^7 LD_{50} by the latter route. All surviving animals reacted by development of high titers of specific complement-fixation and neutralizing antibodies. The complement - fixation antibodies were evanescent but the neutralizing antibodies tended to remain at high titer.

Others have reported 2 of 24 of this species and one of 6 white-tailed jack rabbits (*L. townsendi*) as having antibodies for WEE virus in Weld County, Colorado (Hutson *et al.*, 1951), and 2 of 12 black-tailed jack rabbits as having antibodies for both WEE and St. Louis virus in Washington (Hammon *et al.*, 1942).

Serological studies on sera from hares have shown that complement-fixation and mouse-neutralization tests for presence of WEE and spotted fever antibodies are not in complete agreement, though there is good correlation.

No published records of infestations of man by *D. parumapertus* have appeared, but since the common tick parasite of man, *D. andersoni*, also infests black-tailed jack rabbits in some areas where the ranges of these two tick species overlap, data on infection in the former are of more than academic interest. This is the first time that *D. parumapertus* has been shown to be naturally infected with *B. tularense*, rickettsiae, and Colorado tick fever virus.[2]

The soft tick, *O. lagophilus*, is confined to lagomorph hosts as far as is known and has also recently been reported as being naturally infected with spotted fever rickettsia in Mexico (Silva-Goytia and Elizondo, 1952). Our observations are the first to demonstrate this species to be naturally infected with Colorado tick fever virus.

The present laboratory study of strains of the spotted fever-like agent isolated from *D. parumapertus* indicates there is a third divergence in virulence of agents of this rickettsial group recovered from North American ticks other than in the classical vectors, *D. andersoni* and *D. variabilis*. The other two lines of divergence are represented by agents from *Amblyomma maculatum* and *Haemaphysalis leporis - palustris* (Parker *et al.*, 1939, 1951), the tick vectors of which also customarily infest hosts other than man. Further study will be needed to clarify the exact relationships of this group of rickettsial agents. Parker *et al.*, (1933) showed that *D. parumapertus* can transmit virulent laboratory strains of *R. rickettsii*.

The surprising finding of three hares collected from one ranch in 1951 whose sera agglutinated *Br. abortus* antigen in titers of 1:80 but were completely negative for *B. tularense* is recorded but unexplained. Brucellosis has been reported by Jacotot *et al.*, (1951) in wild hares in France.

It is possible that a widespread decrease in the number of hares following

[2] Four isolates of Colorado tick fever virus were also recovered from *D. andersoni* collected from range horses incidental to these studies in the Battle Mountain area.

peak abundance is due to a combination of environmental pressures such as disease, parasitism and predation rather than to any single factor. It may be true as Hewitt (1921) stated that, "The cause of the sudden plague which kills off the rabbits when they reach their greatest abundance . . . is probably of a multiple nature."

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SUMMARY

Black-tailed jack rabbits in northern Nevada were observed for evidence of contact with disease and arthropod parasites during a peak population. Sera collected during the summers of 1951 and 1952 had no agglutinins against *B. tularense*, but had antibodies against western equine encephalomyelitis and Colorado tick fever viruses, spotted fever-like rickettsia, and *Br. abortus*. Isolations of *B. tularense*, a rickettsial agent related to Rocky Mountain spotted fever, and the virus of Colorado tick fever, were obtained for the first time from the rabbit tick, *Dermacentor parumapertus*, parasitizing these hares. The soft tick, *Otobius lagophilus*, was also apparently infected with the last two pathogens.

The cause of localized decimation among hares in 1951 was not determined. In 1952, hares in some areas had excessive infestations of *Cuterebra* bot parasites causing some deaths. Ticks were not unusually abundant in either year.

The influence of any of these factors on generalized die-off, or directly or indirectly on human disease in northern Nevada was not determined.

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SOME SUGGESTED RELATIONS OF PRAIRIE CHICKEN ABUNDANCE TO PHYSICAL FACTORS, ESPECIALLY RAINFALL AND SOLAR RADIATION

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One of the important problems of wildlife management is concerned with fecundity and variations in fecundity of game animals. However, data on the number of young produced by individual game mammals and birds year after year are still wholly inadequate. This puts the game manager in the position of a man who struggles to keep his checking account safe without knowing what his deposits are. Undoubtedly, from 20 to 40 years of annual censusing of populations would be very illuminating but experimental studies based upon short-term census findings can probably greatly enhance our understanding of all phases of the problems, especially in the field of fecundity.

Leads which concern fertile areas for experimental study will come out of census studies if records of general weather conditions which include solar radiation and portions of its spectrum accompany the census work. The recording of temperature and moisture conditions in connection with ecological studies appears to have been omitted more and more often in recent years.

This probably relates directly to the fact that, taken separately and graphed in the usual linear manner, neither temperature, nor rainfall, nor humidity ordinarily shows a clear correlation with population size. This lack of correlation commonly results from physiological characters of the plants or animals under study which often result in modification of the effect of one factor by the impact of another. The effect of temperature is in part controlled by the moisture present. Two factors which operate in this way have been called paired factors.

The size of populations of some birds appears to be related to physical factors, such as temperature and moisture in some cases (Steggerda, 1929), and the amount and intensity of solar radiation in others (Shelford, 1952). Usually two factors which operate as a pair are involved. This pairing is brought out by figures such as the three in this paper. The simplest form of paired-factor diagram was developed by Johnson (1924, p. 492) in a study of the relations of climate to the production of lambs for market. He showed three concentric areas on a temperature-rainfall chart (similar to Figs. 1, 2, and 3) as follows: (a) the optimum for lambs in the center, (b) the limits within which lambs can be produced, and (c) the climate of the area.

Paired-factor curves are usually drawn

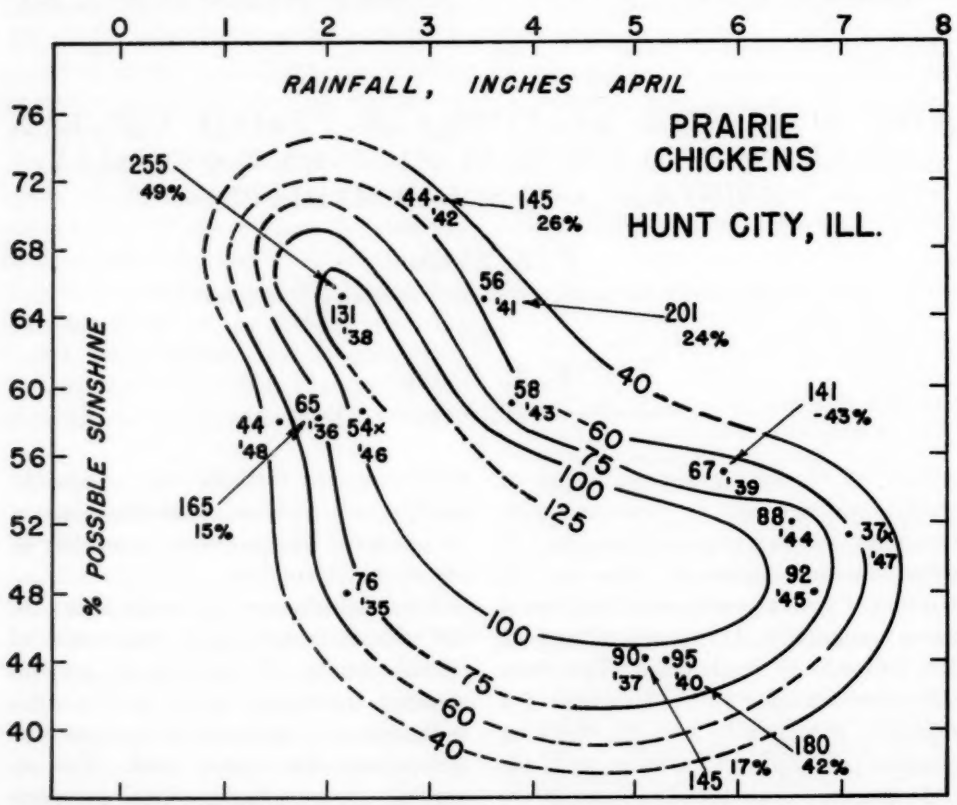

FIG. 1. Diagram showing reproductive response to sunlight and rainfall based on the number of blooming male prairie chickens on the census area in the early spring following the sensitive breeding periods of 1935–1948 near Hunt City, Illinois. The figures arranged around the diagram are estimates of fall populations of both males and females (see text).

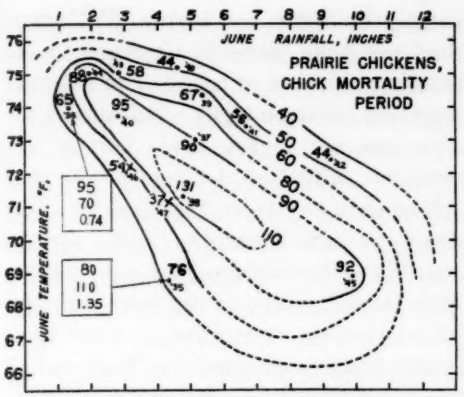

FIG. 2. Diagram relating survival to temperature and rainfall in the post-hatching period of the Hunt City prairie chickens based on the number of booming males present the following spring. The boxed figures are explained in the text.

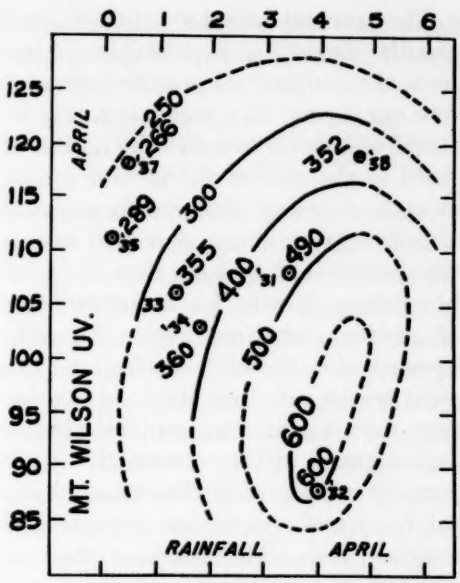

FIG. 3. A suggested diagram showing the relation of reproductive response to ultraviolet radiation and rainfall for the lesser prairie chicken from the data of Davison (1940). Unfortunately there are too few data and spring counts only. The population of the following year is plotted on the factor coordinates.

in more detail than Johnson's three-area diagrams. The optimum conditions and largest population are in the center, as indicated in Figs. 1, 2, and 3, and the lower populations fall near the lines marked, 40, 60, etc. in Figs. 1 and 2. Pierce (1916) was probably the first to draw a paired-factor response diagram, and since then such response diagrams have been drawn for about 25 species of animals and one or more plants by various authors. The majority of them are concerned with temperature and moisture in some form and are called thermohydrograms by European experimental investigators. They include 10 combinations of physical factors. Merriman and Schedle (1941) found the joint action of temperature and light was necessary for sexual maturation of the four-spined stickleback, *Apteles quadracus* (Mitchill). Their bibliography refers to several other cases of paired factors among lower vertebrates.

In respect to the influence of physical factors it should be noted that several investigators have recognized not only paired factors but also master factors (Larsen, 1943). The term "master factors" is applied either to physical or shelter factors or to internal physiological factors such as hunger, and is one which predominates over others, even one of the pair. It is usually the one of the pair with which a linear graph shows an occasional correlation of the biological phenomenon under consideration.

There is some physiological background for anticipating suggested relationships, and the diagrams are drawn with reference to sensitive periods indicated by inference from other birds and by direct observations (Yeatter). Johnson (1924) showed that there are three critical periods in the annual weather cycle for sheep: (a) the rutting period, (b) the lambing period, and (c) the early life of the lambs, which he considered with lambing.

The general development of bird gonads suggests that there is an important period of two or more weeks before egg laying. In a population this interval is about a month—the month of April in the case of the greater prairie chicken, *Tympanuchus cupido pinnatus* (Brewster), in Illinois. A second important period is at, or soon after, the time of hatching. Yeatter has found evidence of another sensitive period in midsummer when the birds are from four to eight weeks old. In a study of population fluctuations, the various physiological states in the reproductive cycle must be considered in relation to physical factors of the annual climatic and weather cycle. The possible effect of weather on cover, food, and dissemination of parasites should not be neglected. Important periods, in addition to those of spring and mid-summer, may occur in winter.

The importance of light is emphasized by nearly every author who has considered it. Whetham (1933) stated that the domestic fowl has a very delicate reaction to light. If the lights are not of sufficiently stimulating power the birds may not leave their perches in the morning. She believed that the fowl is sensitive to and reacts to light of a certain degree of intensity or kind of ray, and noted that the reaction appears to come at a certain level or critical point. There is stimulation to activity above a certain level, and to rest below that level.

Increased egg production is commonly associated with additional hours of artificial light and greater food consumption. It has been assumed that greater egg production is a direct result of additional food. However, Whetham stated that light increases egg production which in turn increases the demand for food and added that laying birds show far more keenness for their food than those which are not laying. Fattening does not take place in response to increasing light but stimulates an internal secretion of the anterior pituitary which activates the ovary and diverts the available nutrition to egg production rather than to accumulation of fat. The supply of such a secretion under certain conditions determines egg production; with large supplies of the secretion, egg production may continue for some time in the absence of adequate food with a concommitant loss in body weight. Whetham quoted Hansson (1930) who stated that in one case illumination alone, without alteration of an unbalanced food ration, resulted in an increase in egg production from 26 to 40 per cent.

Bird gonads increase in size as the sexual products develop. This increase is initiated by a light stimulus, acting through the eye, which causes the anterior pituitary to secrete a hormone. After mating there is an interval of regression during which light has no effect except possibly very near the end of the period, when, as Benoit *et al.* (1950a) discovered in the domestic duck, strong light will cause the gonads to increase. The same authors (1950b) working with measured intensities (648 ergs/second) of 10 different wave lengths from ultraviolet to infrared, each with the same exposure time but under abnormal conditions, found that only orange and red produced an increase in the size of the gonads in the domestic duck. However, an energy of 648 ergs for some of the wave lengths, especially ultraviolet, is far greater than that used on the ferret (see below). There is probably an optimum intensity which is different for each wave length. While the results of these studies are of value, they showed nothing about the number of eggs laid or the vigor of the young.

Recently, Bailey (1950) indicated that ultraviolet light increases egg production in poultry. As has been pointed out, (Shelford, 1951a) ultraviolet light appears to be important for reproduction in the bob-white, *Colinus virginianus* L., and some other animals. For the bob-white, April is considered to be the premating sensitive period for possible ultraviolet reproductive stimulation.

Marshall and Bowden (1934) showed that ultraviolet light is a reproductive stimulus for ferrets in that it shortened the time to estrus, which is the equivalent of egg production. Sabrosky, Larson, and Nabours (1933) made a similar demonstration for a grouse locust, *Acridium arenosum angustum* (Hancock). This species would not breed under ordinary greenhouse conditions but bred after two or more months of exposure to white light in one experiment and to ultraviolet in another. In the case of the white light the results were small. Many more young of greater vigor were produced with ultraviolet. Shelford (1951a) found correlations between populations of chinch bug, *Blissus leucopterus* (Say), and a narrow range of optimum ultraviolet intensity. Bob-white populations showed a similar relation to a narrower range of optimum ultraviolet intensity. The same author suggested (Shelford, 1952) a relationship between the prairie-chicken population in northwestern Indiana and sunshine paired with rainfall.

The greater prairie chicken appears to differ from the bob-white (Shelford, 1951a) in that it is more of an open-grassland species and is subject to greater exposure to sunshine and less rainfall. The Attwater's prairie chicken, *T. c. attwateri* Bendire, is similar to the greater prairie chicken (Lehman, 1941) while the lesser prairie chicken, *T. pallidicinctus* (Ridgway), is still more of an open grassland species than the Illinois bob-white (Davison, 1940).

THE GREATER PRAIRIE CHICKEN IN ILLINOIS

A marked increase in the numbers of prairie chickens in Indiana, Illinois, Missouri, Kansas, and Nebraska in the late 1930's was reported by game technicians during a symposium at Urbana, Illinois, in 1940. The chief remnant of the range of the greater prairie chicken in Illinois is in the south central counties where Yeatter's (1943) studies were made. Since 1875 that area has been an important center of seed production of redtop (*Agrostis alba* Linnaeus), a grass which provides undisturbed nesting cover for prairie chickens during most of the breeding period. During the past 15 or more years there has been a trend toward grain and clover production which has caused a gradual decrease of the acreage in redtop. A decline in the numbers of prairie chicken has been associated with these agricultural changes particularly since 1945. Yeatter's (1943) studies cover the period 1936 through 1953. Numbers of booming males were as follows:

Year	36	37	38	39	40	41	42	43	44
Males	76	65	90	131	67	95	56	44	58
Year	45	46	47	48	49	50	51	52	53
Males	88	92	54	37	44	37	43	40	47

In Illinois, the prairie chicken exhibits three sensitive periods in the physiological cycle as has already been noted for other birds.

THE FIRST SENSITIVE PERIOD — REPRODUCTIVE-CELL DEVELOPMENT PERIOD. This period includes the late stages of reproductive cell development which covers the month of April and is probably very important from the standpoint of population size. The amount of

rainfall at Newton, Illinois, and the percentage of possible sunshine at Terre Haute, Indiana, for April from 1935 through 1948 were utilized in Figure 1. Equal booming-male lines (at intervals) are shown from 40 to 125. To produce a paired-factor diagram for the prairie chicken, the data are plotted on the coordinate points of sunshine and rainfall for the April of the year of breeding. The reproduction of the preceding year largely controlled the spring bob-white population in Missouri (Bennitt 1951). Thus, the 1936 number of booming males was written on the coordinate points for 1935. The figures indicating the breeding season year are marked with an apostrophe; the other figures are the booming males of the following year.

With the exceptions of 1946 and 1947, where another factor (shortage of cover) interfered, the small number of data fell in good order. Such a figure with any approach to equal symmetry cannot be drawn for any other months. No combinations of factors other than sunlight, temperature, and rainfall made possible the drawing of these figures.

As to the discordant values, they are probably the effect of loss of cover as indicated by such discordantly low populations as 54 (1947 arising from 1946) and 37 (1948 arising from 1947). The population for the 1948 breeding period (44 birds) falls in the outer unfavorable zone and compares with the same value for 1942. These discordant values are marked with an X. In Figure 1, the population value for 1947 (54) lies near the line for 100 whereas that for 1948 (37) lies near the line for 60. During the years 1950–1953 (not included in graphs) the number of booming males varied only slightly from 40, a reflection of a continued shortage of nesting cover.

Further inspection of this graph shows that the population values following breeding years 1944 (88), 1945 (92), 1940 (95), and 1937 (90) indicate the general curvature in the lower right portion of Figure 1, whereas the values for 1942 (44) and 1948 (44) fall in the outer zone (upper left) under two pairs of conditions. The value for 1936 (65) is too low for the area in which it falls but an increase of 10 per cent would make it 72 and well placed. The value for 1935 (76) is too high for the area in which it falls but a decrease of 10 per cent would make it 68 which would be more nearly correct. Again the value for 1943 (58) is too low but an increase of 10 per cent would make it 64 and it would fall more nearly in line. This figure could be redrawn as a nearly perfect ellipse and the deviation figured. However, even studies with very large numbers of data, such as Huntington's data for France and Italy (1919, p. 252) which were based on 3,700,000 human deaths, showed noteworthy irregularities. A study of the literature dealing with such diagrams suggests that the paired factors commonly take care of 70 to 90 per cent of the effects of external factors. The remainder is due to other factors. In the case of prairie chickens in Illinois, the usual effects of sunshine and rain hold good only so long as there is plenty of cover.

There are only a few data on the autumn population of prairie chickens. From Yeatter's work there is an estimate for two years on an Illinois study area. The figures arranged around the diagram are estimates of fall populations for the years 1936–1942. Accompanying these population figures are calculated percentages of population increase from prenesting period to fall (Errington 1945, based on the data of Yeatter.)

Post-breeding (third week in July)

age ratios of prairie chickens in Jasper County in 1935 and 1936 were found to be respectively 1.38 young per adult and 0.74 young per adult. From these ratios the population of the Jasper County study area in October 1935 was estimated to be 110 young and 80 adults, and in October 1936, 70 young and 95 adults (165 on Figure 1; the populations and ratios are boxed in on Fig. 2.). These population figures for the study area were erroneously stated (Yeatter, 1943) to be for July. The above figures and subsequent observations indicate a significant variation apparently caused by a number of factors. These figures and estimates by Errington (1945, p. 18, Fig. 7) are shown for one overlapping year (1936) and six additional years around the margins of the diagram in Figure 1. These data can be used to make an sunlight-rainfall diagram for fall population in which the depression facing the upper right hand corner would be eliminated.

Evidently until the mid-1940's, between 200 and 250 prairie chickens did not approach the carrying capacity (in a general sense combining the European idea with that of Errington) of the Hunt City area. This is the reverse of the condition shown in the data of Errington (1945) for the bob-white at Prairie du Sac, Wisconsin, and Des Moines, Iowa, as interpreted by Shelford (1951a). Here large populations were associated with small percentage increases. It is assumed that the largest populations were above the optimum breeding capacity in the two localities for bob-white. The small increases probably resulted from very large summer mortality or possibly from low nesting success associated with high breeding populations.

THE SECOND SENSITIVE PERIOD — EARLY POST-HATCHING PERIOD. Following the methods used to develop Figure 1, it was found that a sunshine and rainfall diagram for the month of June, which is the period of hatching for the Jasper County area, could not be drawn. However, a tentative temperature-rainfall diagram was practicable (Figure 2). The same two values for booming males for 1946 (54) and 1947 (37) are fully as discordant as in Figure 1, a situation which appears to confirm the idea that they resulted from shortage of cover. The values for 1944 (88), 1940 (95), 1937 (90) and 1945 (92) fall in orderly positions and the values for 1942 (44) and 1948 (44) again fall in the outer zone. Also, the values for 1936 (65) and 1943 (58) are too low and that for 1935 (76) too high; the same suggested allowances of 10 per cent for other factors apply as in Figure 1. The 1938 (131) value is high.

THE THIRD SENSITIVE PERIOD — JUVENILE-MORTALITY PERIOD. Field studies on and near the Hunt City study area in 1935 and 1936 resulted in finding a number of intact but partially decomposed prairie chickens 4 to 8 weeks old which had apparently died from pathological causes (Leigh, 1940). Leopold (1931) and Bennitt and Nagel (1937) reported similar observations in Missouri. There are not sufficient data to justify analysis.

ULTRAVIOLET-RADIATION INTENSITY AND THE LESSER PRAIRIE CHICKEN

Errington (1945) presented tables showing the percentage of summer increase of the bob-white in six or seven localities in Illinois, Iowa, and southern Wisconsin. The number of the items appears sufficient to make the results somewhat significant. There were correlations between the percentage of sum-

mer increases and the April intensities of ultraviolet. For the bob-white the ultraviolet was paired with moisture (Fig. 3). Paired-factor diagrams take the same form as those of several authors and a number of such diagrams for the bob-white populations have been published (Shelford 1951a). Using April rainfall and humidity and April ultraviolet from the Mt. Wilson record as representing the premating sensitive period and the autumn population or percentage increase, diagrams could be drawn (Shelford 1951a, p. 171, 172) from Errington's data. Ultraviolet apparently is not a factor during the summer period.

The data of Davison (1940) on the lesser prairie chicken in Oklahoma when plotted against April rain and Mt. Wilson solar ultraviolet (Fig. 3) give some support to the idea of the importance of ultraviolet. This figure has to be presented with reservations because nearly all of the data fall on the drier side of the diagram.

What little data are available on ultraviolet in the case of the greater prairie chicken at Hunt City fit the diagrams for the bob-white very closely, but most of the data fall on the wetter side of the diagram. Lehman's (1941) data on the Attwater's prairie chicken cover too short a period to be utilizable in paired-factor diagrams.

DISCUSSION

The enormous reproductive capacity of most organisms naturally concentrates attention on the physiology of the reproductive period. In population studies relations to optima, degrees of favorability, and extremes tolerated for the physical factors of the environment must be observed from a physiological viewpoint. Paired-factor diagrams appear to represent physiological relations whenever a sufficiently long record of events is available.

To illustrate the methods, we have utilized all available information to present two graphs; a third graph is suggested, but with reservation. In most cases the premating period and period of young-bird mortality are known to a certain extent and some idea may be had about factors which influence population size. Critical months were selected by Johnson (1924) and very advantageously utilized (Shelford, 1951a, 1951b).

Solar ultraviolet appears to be important. There are three separate usable records of ultraviolet intensity; but only the first covers a sufficiently long period to be generally usable: (a) Pettit's Mt. Wilson, California, indices (or ratios) of astronomical intensity made on favorable days was published by the International Astronomical Union 1925–1938, (b) Luckiesh's (1946) Cleveland, Ohio, measurements aimed at an understanding of erythema based on hourly readings from 9 A.M. to 5 P.M. (the summation units are called E-vitons), and (c) Coblentz's (1945, 1952) measurements given in terms of energy (1941–1950). Coblentz's readings were continuously recorded and expressed in terms of accumulated energy in milliwatt minutes per square centimeter. This method of recording is essential in accurate biological research. Coblentz finds a constant ratio between total energy and ultraviolet.

Records of sunshine, humidity, and, in a lesser degree, temperature should not be used without a study of local cloud prevailing movements. Usually the nearest station should be chosen. Cloud movements influence the choice of sunshine stations.

Since life histories, sensitive periods, paired factors, and optimal range of

factors can be found by the investigator, field records of factors are very valuable. Every field study should be accompanied by instrument readings followed by a rigid analysis. It has been possible to record ultraviolet continuously in relative terms at a laboratory for the past 25 years and now it is possible to do so at a field station. Most instruments can be arranged for weekly or fortnightly servicing.

SUMMARY

The failure of linear graphs of physical conditions to make possible interpretation of year-to-year relations of animal populations to weather and climate is well recognized. There are several separate phases of the problem.

1. There are several sensitive periods influencing the population size, for example, the premating period covering about one month.

2. The pairing of factors, for example, light and rainfall, can be discovered through close study of all data and the preparation of trial paired-factor diagrams.

3. Knowledge of the number of eggs produced per female is important.

4. The size of the new generation in each year must be ascertained. The determination of ratios of young to adults appears obtainable and is an important step in that direction.

5. There should be measurement of light, ultraviolet light, moisture, temperature, etc. on the area of study. The recordings should be made with special reference to sensitive periods.

6. The study should extend over as many years as possible.

7. Experiments to check field findings and readjustment of field methods to fit experimental results are essential.

8. Shortness of the usable population period, lack of on-the-area weather data and, especially, change in cover conditions have introduced difficulties in the paired-factor studies of an Illinois prairie-chicken population. After the change in cover the population varied with reference to a different level and numbers of booming males after 1946 are doubtfully utilizable with concurrent meteorological data for comparison with the years up to and including 1946, except to show the effect of cover. The two paired-factor diagrams are accordingly presented as tentative rather than authoritative. For such studies the importance of areas not disturbed by agricultural trends is evident. The lesser-prairie chicken population diagram is suggestive of the need for longer population studies and on-the-area measurement of solar radiation.

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USE OF PECTORAL SPINES AND VERTEBRAE FOR DETERMINING AGE AND RATE OF GROWTH OF THE CHANNEL CATFISH [1]

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In the management of any species of fish, accurate information on age and growth is needed along with other life history information. When this study of age and rate of growth of the channel catfish, *Ictalurus lacustris punctatus*, was initiated in 1950, there was no record in the literature which described a technique for determining the age of that species. Recently, however, techniques which involve use of different parts of the skeleton have been successful. Appelget and Smith (1951) and Barnickol and Starrett (1951) used vertebrae to determine age and growth of channel catfish in the Mississippi River. Sneed (1951) used the pectoral spine in a study of the growth of channel catfish in Grand Lake, Oklahoma. Pectoral and dorsal spines were employed in a statewide investigation of the growth rate of channel catfish in Oklahoma by Hall and Jenkins (1952), and the dorsal spine was recommended as the better indicator of the two. Jenkins, Leonard, and Hall (1952) used the dorsal spine to determine the age and rate of growth of channel catfish from the Illinois River. However, the values of the characteristics of spines and vertebrae for determining the age of catfish have not been compared.

In this study, both the pectoral spines and the vertebrae were used to determine the age and to calculate the growth rate of the channel catfish. One hundred ninety-five channel catfish were collected from the Niangua Arm of Lake of the Ozarks during the summer of 1950 and 466 fish were taken from the same area in the spring of 1951. Those fish were taken by hoop net, gill net, trap net, set line, and rotenone. Twelve year classes were represented in the samples. During the same period, 161 fish of known age, up to 5 years, were removed from farm ponds near Columbia to provide a check.

Methods

Pectoral spines were sectioned at the distal end of the basal groove (Fig. 1) as

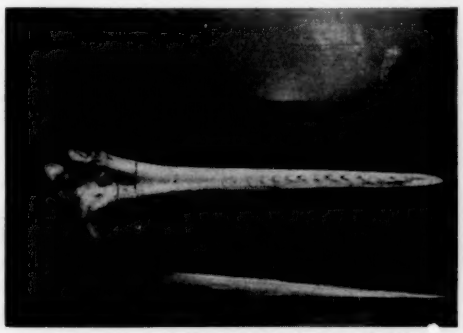

Fig. 1. Posterior view of the left pectoral spine of a channel catfish showing basal groove (A) and the point of sectioning (B).

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proposed by Sneed (1951). The sections were placed in a watch glass containing enough water to cover them and were read without further preparation. Under a binocular microscope with transmitted light, the zones of growth appeared as translucent rings alternating with opaque bands (Fig. 2). The rings were regarded as year marks when they were distinct and appeared in all fields of the section. False marks were incomplete or indistinct.

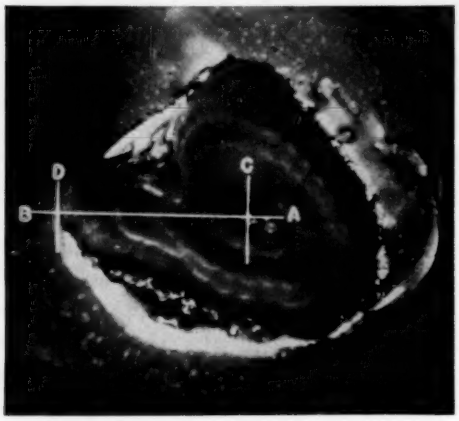

FIG. 2. Pectoral spine section taken from a channel catfish collected in Lake of the Ozarks. The fish was four years old and 9.5 inches in total length. Reference points: AB, posterior radius along which measurements were made; C, center of lumen; D, edge of section.

The vertebrae were disjointed after drying, which usually left the centrum smooth and clean. The fifth vertebra of each specimen (also chosen for study by Appelget and Smith, 1951), was examined under a binocular microscope by reflected light. The arrangement of growth zones was identical with those on the spine sections, but reflected light caused the translucent rings to appear dark and the opaque bands white (Fig. 3). True annual rings were distinct, complete, and often accompanied by a change in elevation of the surface of the centrum.

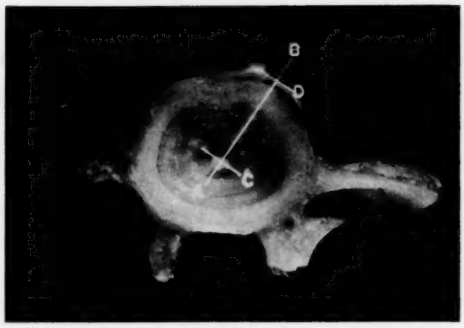

FIG. 3. Fifth vertebra from the same fish described in Fig. 2. Reference points: AB, radius along which measurements were made; C, center, D, edge.

Measurements along radius AB (Figs. 2 and 3) were made with an ocular micrometer which contained a movable scale. When age was assigned to fish, January 1 was considered as the birth date.

AGE DETERMINATION FROM SPINES AND VERTEBRAE

The annual marks on cross sections of pectoral spines of known-age fish were distinct and agreed in number with their known age. There was no question concerning the number or identity of winter and summer growth zones. This fact, coupled with the low incidence of false rings, indicated that growth marks on the spine were reliable for indicating age of channel catfish.

Distinct annual marks were present on the vertebral centra of known-age fish; but false rings occurred more frequently on the vertebral centra than on the spines and some of the false rings exhibited all the characteristics of true annual marks. Nevertheless, the close agreement of the number of annual marks with the known age of the fish indicated that seasonal marks on the vertebrae were satisfactory for aging channel catfish.

Annual marks on whole centra and

sections of spines from fish of the Niangua Arm collections were not as clearly defined as those on the known-age material. The age assessments of all the fish from Niangua Arm were made independently from spines and from vertebrae before the results were compared. There was agreement between the two methods in 85 per cent of the cases in the combined 1950 and 1951 samples.

When the spine section and vertebra of the same fish were compared, agreement in age was effected for an additional 7 per cent of the fish. Fewer than one per cent of the bones were discarded as unsuitable because of malformations. The remaining 7 per cent could not be brought into agreement and were rejected.

Age determinations were supported further by agreement between the peaks of a length-frequency distribution of the sample and the modes of length frequency of age groups. The extent of agreement in the 1951 sample is shown in Figure 4 and was equally good in the 1950 sample. Age groups X, XI and XII are omitted in Fig. 4 and in subsequent tables and figures because of small sample size.

Both vertebrae and pectoral spines were satisfactory for determining the age of channel catfish; however, the spines were preferred since they were collected with less time and effort, required no preparation other than sectioning, contained distinct annual marks, and had few false marks. Deterioration of tissue around the lumen in spines from older fish partially obliterated the first annual mark. This did not prevent accurate aging but did interfere with measurement of the first year's growth of age groups VII, VIII and IX. Vertebrae were more difficult to remove from the fish, occasionally required cleaning, and frequently contained false marks. The vertebrae did record permanently the first annual mark.

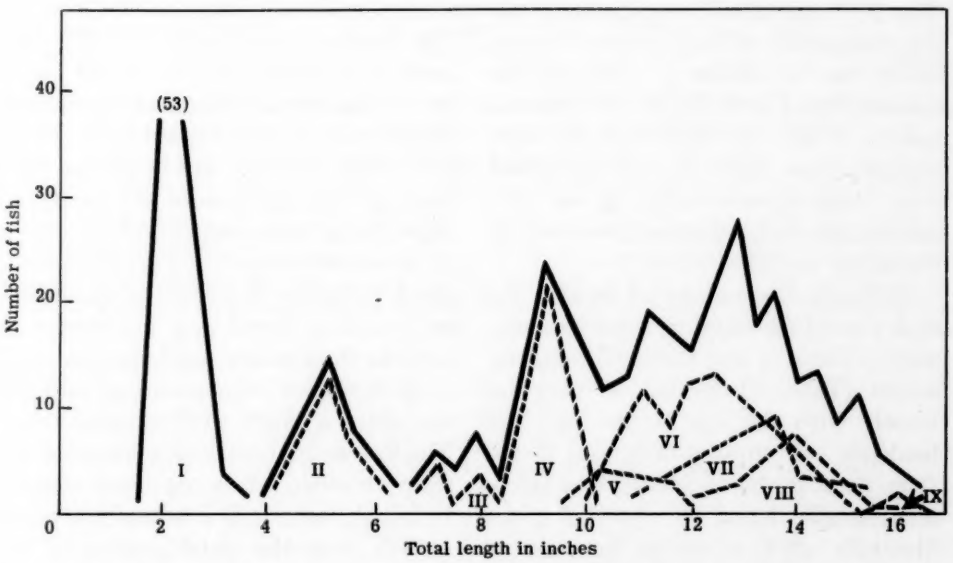

FIG. 4. Length frequency distribution (solid line) and the length frequency distribution within age groups (broken line) of the 1951 sample of channel catfish, Niangua Arm of Lake of the Ozarks. Roman numerals indicate successive age classes.

CALCULATION OF GROWTH

The calculation of growth was based on catfish collected in 1951 in which there was agreement between the seasonal marks on the vertebrae and on the spine sections. Intervals of total body length were plotted against corresponding radial measurements of spine sections (Fig. 5) and of vertebral centra

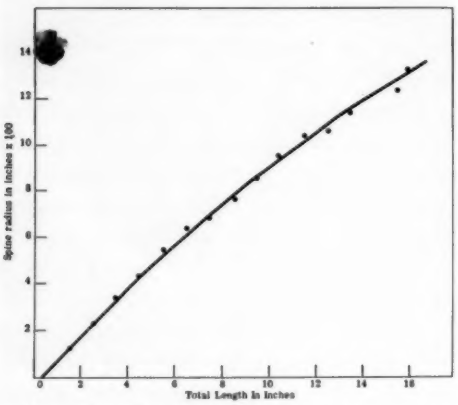

FIG. 5. Relationship of body length to spine radius in 434 channel catfish collected in May-June, 1951.

(Fig. 6). From this it was apparent that the relationship of body length to spine radius was curvilinear in form and the relationship of body length to vertebral radius could be described by two straight lines. Growth was calculated from radial measurements by use of a nomograph similar to that described by Carlander and Smith (1944).

Although the calculated lengths for each year of life based on spine measurements (Table 1) and vertebral measurements (Table 2) tended to vary inversely with the age of the fish, this tendency was most pronounced in the spine data. It was concluded that calculated lengths based on vertebral measurements offer a better measure of growth history than do calculated lengths based on spine measurements. Evidence suggests that the greater

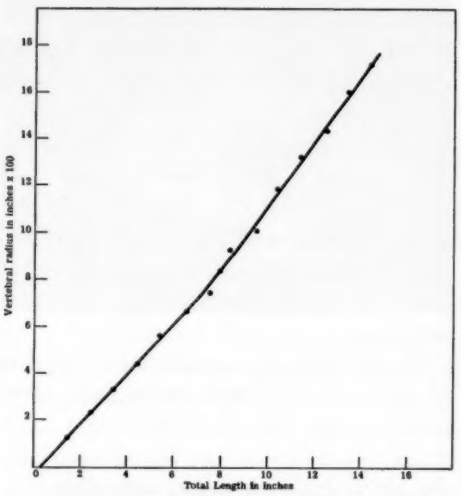

FIG. 6. Relationship of body length to vertebral radius in 434 channel catfish collected in May-June, 1951.

variations in spine data result from the structure and manner of growth of the spine.

The spine retains essentially the same form throughout life. Transverse and longitudinal sections of the spine suggest that growth is accomplished by seasonal deposit of tissue on the outside. The basal groove continues within the spine as a central lumen. As the spine grows this lumen enlarges at the expense of the earliest bone deposits. The basal groove also enlarges and lengthens with spine growth. Because of this lengthening of the groove, the point of sectioning in successive years is moved distally along the spine. Evidence of this distal movement is found in a comparison of sections from young and from older fish. A spine section from a one-year-old fish resembles a heart with unequal lobes. The first annual mark in a spine section from an older fish is not heart shaped, but oval, because it is actually a cross-section from the distal portion of the first year's growth.

An example of the effect of the distal movement of the point of sectioning on

growth calculations is shown in Figure 7. The body-spine relationship is based on measurements from sections A, B, C, and D from 1-, 2-, 3-, and 4-year-old fish respectively. However, section D intersects the 1st, 2nd-, and 3rd-year growth strata along line EF where the radii of these earlier growth zones have decreased due to the taper of the spine. When these decreased radial measurements were employed in a nomograph the resulting calculated lengths were too short.

A cross-section of any pectoral or dorsal spine would contain comparable areas of growth if the point of sectioning remained constant with respect to each year's growth. The same would hold true if the spine were cylindrical instead of conical. It is possible that measure-

TABLE 1.—AVERAGE TOTAL LENGTH (INCHES) AT THE END OF EACH YEAR OF LIFE, CALCULATED FROM SPINE MEASUREMENTS OF 434 CHANNEL CATFISH TAKEN IN LAKE OF THE OZARKS IN 1951

Age group	Number of fish	Average length at capture (May-June)	Year of life							
			1	2	3	4	5	6	7	8
I	53	2.5	...	...	...	...	...	...	...	...
II	50	5.2	2.4	...	...	...	...	...	...	...
III	14	7.6	2.0	5.0	...	...	...	...	...	...
IV	66	9.3	2.0	4.8	7.2	...	...	...	...	...
V	17	10.9	2.1	4.6	6.9	8.9	...	...	...	...
VI	102	12.5	1.9	4.1	6.2	8.1	10.4	...	...	...
VII	64	13.6	...	4.0	5.9	7.8	9.5	11.4	...	...
VIII	52	14.4	...	4.0	5.3	7.0	8.6	10.2	11.8	...
IX	16	14.8	...	3.7	5.4	6.8	8.3	9.8	11.3	13.0
Average calculated length			2.1	4.3	6.1	7.7	9.2	10.4	11.5	13.0
Average annual increment			2.1	2.2	1.8	1.6	1.5	1.2	1.1	1.5

TABLE 2.—AVERAGE TOTAL LENGTH (INCHES) AT THE END OF EACH YEAR OF LIFE, CALCULATED FROM VERTEBRAL MEASUREMENTS OF 434 CHANNEL CATFISH TAKEN IN LAKE OF THE OZARKS IN 1951

Age group	Number of fish	Average length at capture (May-June)	Year of life							
			1	2	3	4	5	6	7	8
I	53	2.5	...	...	...	...	...	...	...	...
II	50	5.2	2.3	...	...	...	...	...	...	...
III	14	7.6	2.3	4.9	...	...	...	...	...	...
IV	66	9.3	2.3	5.0	7.1	...	...	...	...	...
V	17	10.9	2.0	4.9	6.8	8.5	...	...	...	...
VI	102	12.5	2.0	4.6	6.9	8.5	10.1	...	...	...
VII	64	13.6	2.1	4.7	6.8	8.5	10.0	11.6	...	...
VIII	52	14.4	2.0	4.3	6.3	7.9	9.1	10.3	11.9	...
IX	16	14.8	2.1	4.1	5.6	7.2	8.8	10.0	11.1	12.8
Average calculated length			2.1	4.6	6.6	8.1	9.5	10.6	11.6	12.8
Average annual increment			2.1	2.5	2.0	1.5	1.4	1.1	1.0	1.2

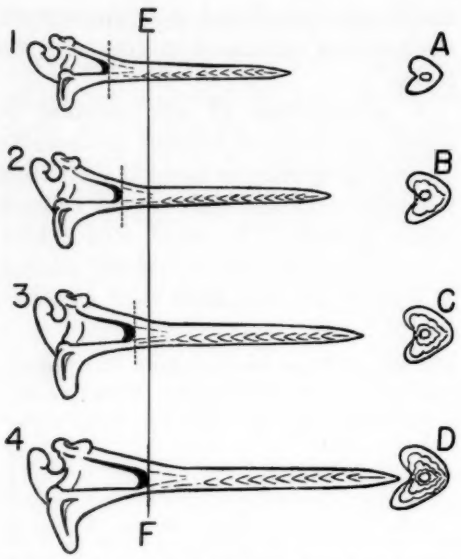

FIG. 7. Whole catfish spines of ages 1 to 4 years inclusive and cross sections. Sections A, B, C, and D are from spines 1, 2, 3, and 4 respectively and were cut at the end of the basal groove as shown by the broken line. Line EF indicates the areas of first, second and third year's growth that appear in section D. Drawing by Charles R. Walker.

ments along the anterior radius would reduce this error, since the growth lines were nearly parallel to the long axis of the spine in this region. The dorsal spine is more regular in shape than the pectoral spine and would probably be better for measurement of growth. Only a few dorsal spines were sectioned and comparison of the two kinds of spines was not possible.

The rate of growth calculated from vertebral measurements was more uniform, and in closer agreement with empirical measurements than was the growth history calculated from spine measurements. Because the spine method, as used in this study, has an inherent defect, it appears that the use of vertebrae resulted in a more accurate approximation of growth. Modification of the spine technique by measurement along the anterior radius might minimize this error and allow reasonably accurate calculations of growth from spine sections.

SUMMARY

1. Vertebrae and pectoral spines were used in a study of the age and growth of 661 channel catfish taken from the Niangua Arm of the Lake of the Ozarks.

2. Each structure contained annular marks which were shown to be true year marks by the usual tests of validity. This was further substantiated through the study of the same structures from 161 channel catfish of known age.

3. From the standpoint of collection, preparation, and reading, pectoral spine sections were preferred over the vertebrae as they required the least expenditure of time and effort in preparation and were more reliable for age determination because they showed fewer false marks. Deterioration of tissue around the spine lumen obscured part of the first annual mark in older fish. This did not prevent aging but did make the measurement of the first year growth less accurate.

4. The relationship of body length to spine radius appeared to be curvilinear. The relationship of body length to vertebral radius was best described as two straight lines.

5. Growth data derived from vertebral measurements was thought to be the better approximation of growth history for the following reasons: (1) growth was more uniform and in better agreement with the empirical data; (2) the spine method, as used in this study, had an unavoidable error that caused calculated lengths to be too short.

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GAME ANIMALS UTILIZED AS FOOD BY THE BOBCAT IN THE SOUTHERN APPALACHIANS[1]

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Management currently emphasizes the encouragement of forest game—principally white-tailed deer, wild turkey, and ruffed grouse—in the national forests of the southern Appalachians. Within this region the bobcat (*Lynx rufus*) is often considered a major predator of game animals. Predation by bobcats upon game is common, but the relative importance of such predation has not been investigated.

The food habits of the bobcat have been studied in California (Dixon, 1925, McLean, 1934, and Leach and Frazier, 1953), Vermont (Hamilton and Hunter, 1939 and Foote, 1945), Michigan (Dearborn, 1932), Minnesota (Rollings, 1945), Massachusetts (Pollack, 1951), and in Missouri (Korschgen, 1952). Forest game, particularly deer, is shown to be important food of bobcats. In the southern Appalachians deer have been increased considerably by management in the last two decades: the role of the bobcat as a predator of deer is now of some concern.

In Virginia the bobcat is a predator of little sport value. In adjacent states it is seldom hunted for sport or trapped for fur. Thus the only control exerted on it is through limited practices of state and federal game agencies. Carcasses taken during these programs were the principal source of material for this study. Additional carcasses were obtained from private hunters and trappers. Through cooperation of the Virginia Commission of Game and Inland

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Fisheries, the North Carolina Wildlife Resources Commission, and various individuals, 80 carcasses and stomachs (42 from Virginia, 38 from North Carolina) were collected from January, 1951 to April, 1952. Fifty-seven stomachs and 50 intestinal tracts from the entire sample contained sufficient food for analyses. Most of the specimens were taken during late fall and winter. Nearly all of them came from wildlife management areas on the George Washington and Thomas Jefferson National Forests in Virginia and the Pisgah and Nantahala National Forests in North Carolina.

Food material in each scat and each stomach was considered to represent a single meal. Each intestinal tract was similarly considered if the food remains differed from that in the corresponding stomach. The material summarized here represents 124 scats, 57 stomachs, and 50 intestinal tracts.

Feeding activities of the bobcat probably vary with the seasons, and this study presents some information regarding these changes. Although stomach and intestinal material was obtained in fall and winter, the scat collection was made throughout the year and should reflect seasonal dietary changes. Because the scat sample was somewhat small, scats were grouped into two periods of the year rather than four: i.e. spring-summer and fall-winter, with March 15 and September 15 separating them. Data for these periods were later adjusted to an annual basis as suggested by Latham (1951).

RESULTS AND DISCUSSION

Game animals of the southern Appalachian bobcat range include quail, woodcock, ruffed grouse, wild-turkey, deer, cottontail rabbit, gray and fox squirrels, raccoon, opossum and foxes. There is some evidence that bobcats may prey upon nearly all of these, but the food analyses failed to indicate game birds as an integral part of the diet. It is interesting to note, however, that three of the bobcats were trapped at the carcass of one wild turkey. Mosby and Handley (1943) alleged that bobcats kill wild turkeys. They cited incidents of bobcats being called up by hunters yelping turkeys, and reported that foxes and bobcats killed 37 liberated captivity-reared wild turkeys in Virginia during the winter of 1940–1941. They considered the bobcat to be one of the principal predators of restocked wild turkeys.

Tables 1 and 2 indicate that game mammals were by far the more important bobcat foods although the influence of this predation on game populations is not known. Food analyses showed that bobcats in Virginia and North Carolina feed on at least seven genera of game mammals. Adjusted figures obtained from scat analyses show game mammals occurred in nearly 98 per cent of the sample, with rabbit and gray squirrel most predominant.

No other animal seems to be more plentiful and readily available to a hunting bobcat than the cottontail rabbit (*Sylvilagus* spp.). Various systems of tabulating data showed that rabbit was the food taken most frequently. It ranked first according to both occurrence and volume, regardless of season. As expected, it was taken more frequently and in greater volume during the spring-summer period when its populations were at an annual peak. A combination of the entire food analyses showed rabbit is perhaps the most important of all bobcat foods (Table 1).

Remains of gray and fox squirrels (*Sciurus carolinensis* and *S. niger*) were observed in the bobcat food material

examined. The gray squirrel is the more abundant of the two within this bobcat range and is second in importance only to cottontail rabbit as a bobcat food.

White-tailed deer (*Odocoileus virginianus*), another important bobcat food, ranked fifth, occurring in nearly 10 per cent of scats. The seasonal variances are indicated in Table 1. Table 2 also suggests deer is an important bobcat food. The data presented do not necessarily infer that deer is regular prey. Field data indicate it is taken more often following the hunting season when carrion is most abundant. It is likely that the lower occurrence in spring represents a truer degree of predation since hair and other remains of fawns were recovered from several of the spring scats. Many competent observers report that bobcats are at times a definite deer predator in the southern Appalachian region. DeGarmo *et al.* (1950) quoted four specific instances of bobcats killing deer in West Virginia. M. G. Edwards, supervisor of the western wildlife management areas in North Carolina, wrote (Personal correspondence dated February 27, 1952), ". . . two of 12 deer released on Hickey's Fork section of the Rich Laurel Area were, from all observations, killed by bobcats three or four days

TABLE 1.—FOOD HABITS OF BOBCATS IN VIRGINIA AS INDICATED BY OCCURRENCE IN 124 SCATS COLLECTED 1951–1952

Food Item	Spring-Summer		Fall-Winter		All Seasons*
	% Vol.	% Occ.	% Vol.	% Occ.	% Occ.
GAME MAMMALS					
Cottontail rabbit (*Sylvilagus* sp.)	52.0	69.8	31.6	39.5	54.6
Gray squirrel (*Sciurus carolinensis*)	16.0	22.6	29.5	35.2	28.9
White-tailed deer (*Odocoileus virginianus*)	1.7	5.7	12.2	14.1	9.9
Fox squirrel (*Sciurus niger*)	8.1	7.5	1.8	1.4	4.5
Opossum (*Didelphis virginianus*)	3.5	3.8	0.4	1.4	2.6
Gray fox (*Urocyon cineroargentus*)	1.4	1.9	....	....	0.9
NON-GAME MAMMALS					
Meadow mouse (*Microtus pennsylvanicus*)	1.7	11.3	5.9	9.9	10.5
Woodchuck (*Marmota monax*)	10.5	5.7	9.2	7.0	6.3
Chipmunk (*Tamias striatus*)	1.2	5.7	3.4	5.6	5.7
Red squirrel (*Tamiasciurus hudsonicus*)	....	....	4.3	7.0	3.5
Unidentified mammal	....	....	1.2	1.4	0.7
White-footed mouse (*Peromyscus* sp.)	....	....	trace	1.4	0.7
Unidentified shrew	....	....	trace	1.4	0.7
Woodrat (*Neotoma magister*)	3.0	1.9	....	....	0.9
NON-GAME BIRDS					
Unidentified bird	trace	16.9	0.3	4.2	10.6
Flicker (*Colaptes auratus*)	....	....	trace	1.4	0.7
Cardinal (*Richmondena cardinalis*)	....	....	trace	1.4	0.7
OTHER ANIMALS					
Various insects	0.3	5.7	....	....	2.9
Rattlesnake (*Crotalus horridus*)	0.2	3.8	....	....	1.9
GRASSES	0.3	7.5	0.2	1.4	4.5

* Figures derived from proportional adjustment.

after their release . . . One was a fawn, . . . The other was a grown doe weighing about 80 pounds. . . ." Edwards further stated that from 1949 to 1951 at least five other deer were killed by bobcats on wildlife areas in North Carolina.

Other game mammals eaten by bobcats (Table 2) include opossum (*Didelphis virginianus*), raccoon (*Procyon lotor*) and gray fox (*Urocyon cineroargentus*); the latter two undoubtedly accidental prey or carrion. Opossum appears to be taken rather consistently, as remains were noted in all sets of analyses. The frequency with which it is consumed implies that it is among the staple bobcat foods.

At least 18 additional species of wild animals were noted in the food samples. Of 13 non-game mammals found in one-third of the samples, nearly 70 per cent

TABLE 2.—FOOD HABITS OF VIRGINIA AND NORTH CAROLINA BOBCATS AS INDICATED BY 233 SAMPLES (124 SCATS, 57 STOMACHS, AND 50 INTESTINAL TRACTS) COLLECTED FROM JANUARY 1951 TO MARCH 1952

Food Item	Percent Occurrence	Percent Volume
GAME MAMMALS		
Cottontail rabbit (*Sylvilagus* sp.)	37.3	30.7
Gray squirrel (*Sciurus carolinensis*)	24.9	16.8
White-tailed deer (*Odocoileus virginianus*)	17.2	11.8
Opossum (*Didelphis virginianus*)	6.5	5.2
Fox squirrel (*Sciurus niger*)	3.4	2.3
Raccoon (*Procyon lotor*)	2.1	10.3
Gray fox (*Urocyon cineroargentus*)	0.9	0.8
NON-GAME MAMMALS		
Meadow mouse (*Microtus pennsylvanicus*)	11.1	3.4
Woodchuck (*Marmota monax*)	5.1	8.5
Chipmunk (*Tamias striatus*)	3.0	1.1
White-footed mouse (*Peromyscus* sp.)	2.6	0.5
Flying squirrel (*Glaucomys volans*)	2.6	2.2
Red squirrel (*Tamiasciurus hudsonicus*)	2.1	1.3
Unidentified mammal	2.1	0.5
Striped skunk (*Mephitis mephitis*)	1.3	0.5
Pine mouse (*Pitymys pinetorum*)	0.9	0.6
Red-backed mouse (*Clethrionomys gapperi*)	0.9	trace
Woodrat (*Neotoma magister*)	0.4	0.6
Brewer's mole (*Parascalops breweri*)	0.4	0.4
Unidentified shrew	0.4	trace
NON-GAME BIRDS		
Unidentified bird	6.9	0.5
Flicker (*Colaptes auratus*)	1.3	0.6
Cardinal (*Richmondena cardinalis*)	0.4	trace
Ruby-crowned kinglet (*Regulus calendula*)	0.4	trace
OTHER ANIMALS		
Various insects	2.1	trace
Rattlesnake (*Crotalus horridus*)	0.9	trace
Unidentified snake	0.4	0.3
Unidentified snail	0.4	trace
GRASSES	3.4	0.8

were rodents. Meadow mouse (*Microtus pennsylvanicus*) occurred most frequently and regularly in all seasons although woodchuck (*Marmota monax*) was found in greater bulk. However, because of its period of hibernation, the latter was believed to be a seasonal food in spite of data presented in Table 2. Other mammals in this group preyed upon by bobcats to a lesser degree are included in Table 2. The importance of these non-game mammals, especially the smaller ones, is that they serve as buffer foods when game animals are more difficult to obtain.

Analyses revealed but few song birds among the bobcat foods. In general birds appeared in less than 10 per cent of the entire sample.

SUMMARY

Food habits of the bobcat (*Lynx rufus*) in the southern Appalachian Mountain region (Virginia and North Carolina) were determined through the examination of 57 stomachs, 50 intestines, and 124 scats collected from January, 1951 to April, 1952. Twenty-six different food items were identified. Game mammals occurred in over 92 per cent of the entire sample, non-game mammals and birds in nearly 42 per cent, and other animals and grasses in less than 8 per cent. It is concluded that cottontail rabbit and gray squirrel are the most important bobcat foods in this region. Although deer was eaten quite frequently, it was considered to be more as carrion than as freshly killed prey.

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FACTORS INFLUENCING THE FALL ROADSIDE PHEASANT CENSUS IN IOWA [1]

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A basic step in the management of a game species, such as the ring-necked pheasant (*Phasianus colchicus*), is the development of inventory techniques which are comparatively simple in field application, reasonably accurate, and adaptable to large areas. The need for such a method of censusing pheasant populations has resulted in the widespread use of the fall roadside census technique developed by Bennett and Hendrickson (1938) in Iowa. The census has been used as an index for comparing relative abundance of pheasants from year to year.

The recent evaluation of the fall roadside census in Iowa, for the period 1936–1950, (Kozicky, *et al.*, 1952) showed that large samples are needed to reflect population trends. Also, the relative efficiency of various numbers and lengths of routes was discussed. Inasmuch as many known variables affected the count for any census route, a more adequate control of those factors would tend to decrease the size of sample needed for various levels of statistical reliability. A current administrative objection to the fall roadside census in Iowa is that it is conducted so late in the fall that the results are not available for regulatory action. The determination of the effects of climatological and time factors, agricultural practices, and changes in the population level upon the number of pheasants observed during roadside counts has been based upon qualitative data.

The present study resulted from the need for a quantitative investigation into the influence of various physical, agricultural, and seasonal factors and was centered about the Winnebago Pheasant Research Area in north-central Iowa (Baskett, 1947). The topography is level to gently rolling, and about 95 per cent of the land is farmed. In 1952, the average 160-acre farm on the census area had 59 acres in corn; 38 acres in small grains, mostly oats; 17 acres in soybeans; 16 acres in hay; 19 acres in pasture; and 11 acres in miscellaneous use, such as groves, feed lots, buildings, lanes, etc.

Techniques of Investigation

Two 30-mile routes were selected in order to serve as a check on each other in the statistical analysis of the data. Since the counts were to be made regardless of existing weather conditions, only all-weather roads were selected. The two routes were driven on alternate mornings. In order to evaluate the time-

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of-day effect, the route was run in the opposite direction from the previous time over that route. Counts were made every morning during the three-month study period extending from August 1 to October 31, 1952. They were conducted from a car driven at the rate of 5 minutes per mile, or 12 miles per hour. The census was started exactly at sunrise each morning and was completed two and one-half hours later.

Weather data collected daily before and after the counts included: temperature, wind velocity and direction, relative humidity, precipitation, cloudiness (on a 0–10 scale) and barometric pressure. Barometer readings were made 15 minutes before and 15 minutes after the count and the difference between these two readings was used as a measure of the rate of atmospheric pressure change. Dew measurements were made immediately before the census was begun.

There was an evident need for a simple, quantitative method of measuring dewfall. Previous workers with the roadside census reported dew amounts in such qualitative terms as absent-light - medium - heavy (Fisher, *et al.*, 1947), absent or present (Kozicky, 1952), or specifying that counts should be made on mornings with a "normal" dew (Randall and Bennett, 1939). In the search for a quantitative method, it was found that Duvdevani (1947) had developed an optical method for measuring dewfall based upon comparison of size, form, and distribution of dew drops precipitated on a standard surface with a series of standard photographs which depicted different known amounts of dew. He adopted as the standard dew gauge a rectangular wooden block, 32 x 5 x 2.5 cm., coated with a special red paint. Each photograph was given a "dew scale number" from 1 to 8. The number which indicated the amount of dew was determined by direct visual comparison of the dew deposit on the surface of the block with the atlas of full-size photographs.

The manner of exposing and the location of the dew block were quite important. The most logical location for the block, the roadside ditch, was completely unsatisfactory; the passing of a single car during the night would cause the deposit of enough dust to completely disrupt the dew picture. The most satisfactory location for exposure of the block was a large, open, closely mowed area in a farmer's front lawn and the block was placed in this location each evening at sunset.

As is inherent in the process of estimation, it would be expected that the estimate of dew by one person might differ from that of another. However, Duvdevani (1947) found that only in extreme borderline cases were there any discrepancies. He concluded that if reference was made to the dew atlas at each observation, it could be assumed that the error injected by several observers making the measurements would not be significant. No quantitative method of measuring frost was found.

The 60 miles comprising the census routes were numbered and separate records were kept for each mile. If possible, the sex of all pheasants observed was noted. The age and size of brood were recorded for young birds and any adults with the brood noted. A binocular was used, if necessary, as an aid to determine sex or age but not to find pheasants. No effort was made to limit the width of observation, and no efforts were made to deliberately flush birds from cover. Pheasants observed were noted as occurring within or outside the road right-of-way. Cover conditions were recorded daily by the approximate percentage of the various agricultural

operations (fall-plowing, soy-bean and corn harvest, etc.) which had been completed within each mile.

EFFECT OF CLIMATOLOGICAL FACTORS

In order to find the particular linear function which best estimated the true condition in the population under study, the method of multiple linear regression (Snedecor, 1946) was used. Certain variables were eliminated in order to reduce the amount of computation and to facilitate handling of the data.

Rain falling at any time while the census was in progress disrupted the count completely (coefficient of variation, 52.7 per cent). The impairment of visibility alone would explain this lack of accuracy, regardless of the effect upon the pheasants. Rain during the night preceding the census, though not while the count was actually being made, also had an adverse effect (coefficient of variation, 58.3 per cent). Regardless of the amount of rain, the counts never approached the magnitude of those made on mornings with heavy dews. Although a general trend toward seeing larger numbers of birds with increasing amounts of precipitation (or a combination of dew and precipitation) appeared to exist, the difficulty in analyzing the data on a comparable basis with other counts warranted the rejection of such censuses.

Counts made when fog was present were deleted for lack of visibility. Comparison with other censuses made under the same dew conditions showed the counts made under foggy conditions to be significantly lower at the one per cent probability level than would be expected were fog absent and the other factors held the same.

Several mornings in October were excluded because of the presence of frost. The lack of a quantitative method of measurement resulted in difficulty in attempting comparisons with other counts.

The influence of wind direction was quite negligible. The actual barometric-pressure reading at the start of the census showed no relationship to the count.

After elimination of the six previously discussed factors, six variables remained to be analyzed for their relationship to the mean number of pheasants observed per mile (Y). They were: amount of dew (X_1), wind velocity (X_2), relative humidity (X_3), cloudiness (X_4), temperature (X_5), and rate of pressure change (X_6). In the multiple regression analysis, it was assumed that the X's were known constants; that for any particular value of X, Y was normally and independently distributed; and, that the variance of Y for any particular value of X was the same for all X.

The multiple linear regression equation derived for Route 1 was: $Y = 0.757 + 0.984X_1 - 0.095X_2 - 0.020X_3 + 0.049X_4 + 0.034X_5 - 5.183X_6 + 45.953X_7$. A seventh independent variable, the squared value of the rate of pressure change, was included in the analysis. This was done because the correlation between the squared and unsquared data was 0.614, as compared to values of 0.95 to 0.99 in similar correlations involving the other five factors. This considerable deviation from unity would seem to indicate a possible curvilinear relationship between the birds observed per mile and the rate of pressure change. This trend was not found to be significant, so no further attempts to establish other than a linear relationship were made.

The equation for Route 2 was found to be: $Y = 0.368 + 0.907X_1 - 0.016X_2 + 0.009X_3 - 0.029X_4 + 0.016X_5 + 9.342X_6$.

The coefficient of multiple correlation, R, was equal to 0.969 on Route 1 and 0.930 on Route 2. These measures of the degree of joint linear association among the seven dependent and independent variables (or the degree of linear association in the sample between the estimated and observed number of pheasants per mile) were both found to be significant at the 0.01 probability level. The R^2 value computed for Route 1 was 0.938 and for Route 2, 0.865. Therefore, 93.8 per cent of the variation on Route 1 and 86.5 per cent on Route 2 was due to the influence of the six climatological factors being analyzed.

Although the R values indicated a significant correlation between the number of pheasants counted and the climatological factors as a whole, the possibility was recognized that this may have been due primarily to the influence of only a part of the factors, while the effect of the other factors was negligible. In order to check on such an eventuality, the standard partial regression coefficients (b′) were tested individually for significance (Table 1). It was found that of the six weather factors only dew and temperature were significant on Route 1, and dew alone was significant on Route 2.

The reasons for the difference in the temperature effect, the only area of major disagreement between the two routes, are not readily apparent. Upon examination of the correlation coefficients between the various weather factors, it was found that no significant correlation existed between temperature and any of the other factors on Route 2, but on Route 1 significant correlations at the 0.01 level of temperature with dew and with relative humidity were found. Perhaps, since dew was found to be significant in its relationship to birds observed per mile, the correlation between dew and temperature on Route 1 was reflected in the significance of the temperature effect.

If the portion of information furnished by any two variables tends to be interdependent, the correlation between the two is likely high, and r (or R if more than two variables were involved in the interrelationship) may not be much larger than the correlation of either with the number of birds observed. On Route 1, dew was significantly correlated with every factor except cloudiness. Hence, it was not surprising to find that R (0.969) was little greater than r_{Y1} (0.947). Similarly, on Route 2, R was equal to 0.930 while the correlation of dew with the number of pheasants observed per mile was 0.920. Ap-

TABLE 1.—ANALYSIS OF SOME CLIMATOLOGICAL FACTORS AND THEIR INFLUENCE ON THE FALL ROADSIDE PHEASANT CENSUS, WINNEBAGO COUNTY, IOWA, 1952

Climatological Factor	Route 1			Route 2		
	b′	$s_{b'}$	t	b′	$s_{b'}$	t
Dew	0.934	0.089	10.50*	0.889	0.154	5.79*
Temperature	0.202	0.070	2.90*	0.072	0.089	0.80
Relative humidity	−0.151	0.080	1.89	−0.061	0.169	0.35
Wind velocity	−0.120	0.059	2.03	−0.021	0.102	0.21
Cloudiness	0.085	0.059	1.45	−0.043	0.113	0.38
Pressure change	−0.071	0.071	1.00	0.114	0.106	1.08

* Significant at the 0.01 level.

parently, almost as good a job of estimating can be done with dew alone as the independent variable. The other factors contribute little additional information, even though the temperature effect was found to be significant on Route 1.

To gain a different perspective of the influence of the several weather factors, the simple linear regression of birds per mile on each factor was computed for each route. It was then possible to apply tests to determine if any factor exerted a different effect on one route than on the other. It was found that the differences were not significant in any instance, and it was concluded that the weather factors had the same influence on both routes. The nonsignificant difference in the temperature effect was interesting in view of the fact that the multiple regression analysis showed that temperature had a significant influence on Route 1 but not on Route 2. Apparently, the effect on Route 1 was just enough to be significant, while that on Route 2 was not; yet, the difference between the two was not great enough to be statistically significant.

Since the weather effects on the two routes were statistically the same, data from the two were combined and the linear regression and correlation coefficient were computed for each factor. In this manner, an idea was gained of the effect of each factor when all others were excluded. Such information may be of value in the event measurements on only one or a few of the factors are available, and is of especial interest with respect to dew (Fig. 1) because information on dew alone may be all that is required in correcting for variability in the counts due to weather.

On examination of the correlation coefficient of each factor with birds per mile, it was found that all were significant at the 0.01 probability level except cloudiness. It must be remembered, however, that this individual analysis makes no allowance for the interrelationship existing among the variates. This was done by the multiple regression analysis which should be consulted for the over-all picture.

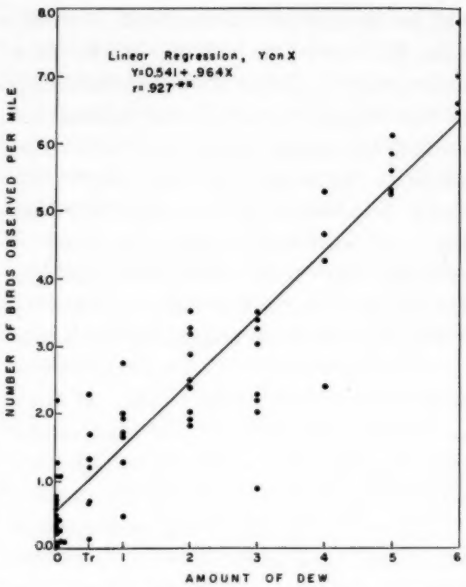

FIG. 1. Effect of dewfall on the fall roadside pheasant census.

To obtain a general idea of the relative importance of the different weather factors as they affect the roadside census, a comparison of the b′ values from Table 1 can be made. These values give the proper comparison (within the limits of sampling variation) because they are without dimensions, as opposed to the b values in the multiple regression equations which have such dimensions as miles per hour, per cent, degrees, hundredths of an inch, etc.

EFFECT OF TIME OF DAY

The effect of time of day was determined separately for the two routes, eliminating those mornings with rain

during and/or before the count, fog, and frost. The mean number of birds counted was computed for each mile when the start was made at Mile 1 (a) and for each mile when the start was at mile 30 (b). These means were adjusted to a constant dew reading. The adjusted means were then used to compute the linear regression of the difference in the number of birds seen for each mile (a-b) on the difference in the time of observation for each mile (a-b). For example, Mile 10 of Route 1 was censused 50 minutes after sunrise when the start was at Mile 1, and a mean of 4.38 birds was seen. When the start was at Mile 30, Mile 10 was censused 105 minutes after sunrise, and a mean of 1.42 birds was seen. Thus, there was a difference of −55 minutes (with respect to sunrise) in the time of observation and a difference of 2.96 in the mean number of birds counted per mile. Similar computations were carried out for each mile.

Statistical analysis revealed that there was no difference between the two routes in the time effect. Therefore, the data from the two were combined and the linear regression and correlation coefficient computed, the latter being significant at the 0.01 level (Fig. 2).

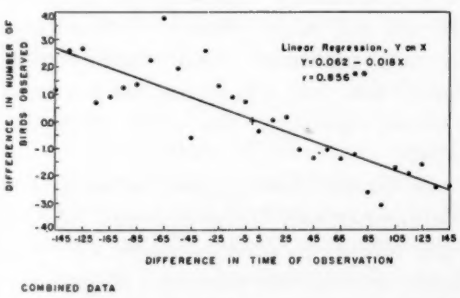

FIG. 2. Effect of time of day on the fall roadside pheasant census (combined data).

It is apparent that time of day did exert an important influence on the fall roadside census. Though it would be possible to make corrections for this effect, it is not necessary. If the census is always conducted at the same time of day with respect to sunrise, the time of day influence will be a constant, which can be disregarded in subsequent analysis of the data. It should be remembered that the roadside census is an index, not a complete census, and the time and computation required to correct for the time-of-day effect would only result in another index figure. Comparison of such correlated counts would not give any more information than could be gained from comparing the original counts.

EFFECT OF SEASON

The fall roadside census in Iowa has generally been conducted in late September and early October. An important aim of this study was to determine if the census could be taken in August, as has been done in Minnesota (Erickson, *et al.*, 1951). If so, this would allow administrators to have the population estimates in sufficient time to give them due consideration in setting hunting regulations.

By comparing the coefficients of variation computed for the different dew readings for each month, it was found that August gave the least variable results (Table 2). It was noted that there was less variation on mornings with heavy dews than on mornings with light or no dew present.

Seasonal changes in cover conditions, brought on primarily by agricultural operations, would be expected to affect the number of birds observed. By August 1, the corn crop had about reached its maximum growth, and the oat harvest had just been completed. Fall plowing of small grain stubble and of some pastures and hayfields constituted the

TABLE 2.—ANALYSIS OF VARIATION IN FALL ROADSIDE PHEASANT COUNTS BY MONTH AND VARYING DEW AMOUNTS, WINNEBAGO COUNTY, IOWA, 1952

Dew	Number of Observations	Mean Birds Per Mile	Standard Deviation	Coefficient of Variation
		August		
0.....	..	....	....	.....
Tr....	1	1.67	....	.....
1.....	2	2.38	0.54	22.69
2.....	4	3.12	0.44	14.10
3.....	2	3.22	0.26	8.07
4.....	1	4.23	....	.....
5.....	5	5.64	0.38	6.74
6.....	2	7.40	0.57	7.70
		September		
0.....	4	0.43	0.47	109.30
Tr....	2	0.95	0.35	36.84
1.....	4	1.63	0.28	17.18
2.....	5	2.19	0.44	20.09
3.....	6	2.36	0.94	39.83
4.....	3	4.10	1.50	36.59
5.....	..	....	....	.....
6.....	2	6.53	0.09	1.38
		October		
0.....	16	0.61	0.54	88.52
Tr....	4	1.12	0.92	82.14
1.....	1	0.43	....	.....

major farming operation during August. The first cutting of corn for ensilage was noted on September 12. About 3 per cent of the corn acreage on the two routes was harvested in this operation and resulted in the complete removal of cover from such fields. The combining of early soy beans commenced on September 17, but the soy-bean harvest was not in full progress until the first week in October. The corn harvest was not fully under way until about October 20.

The period in August during which the roadside census is to be run should be at the same point in the reproductive cycle each year. If the survey is not conducted at the same designated time each year, a large error may be injected into the results. The method for determining the proper time for conducting the roadside count could be based upon a standard interval between the peak of the hatching season and the beginning of the roadside counts. Kimball (1949) suggested a 14-week period between the spring crowing peak and the start of the roadside survey.

The first general killing frost occurred on October 5. This resulted in a considerable flattening of weedy cover and the dropping of leaves, especially those of corn and soy-bean plants. This, along with the discussed agricultural operations, resulted in the creation of many new open areas where the pheasants could be seen more readily.

It is evident that roadside counts made after mid-September would encounter changing cover conditions in several respects with each succeeding day. The least variation in cover conditions was encountered in August, when the only agricultural operation of consequence was fall plowing. Within any two-week period, the amount of fall plowing increased an average of only about 15 per cent.

Constant changes in the pheasant population would be expected to show in the counts. By comparing the mean counts in birds per mile by month for the various dew readings (as given in Table 2), a decline of around 20 per cent from August to September was noted. Brood mortality was believed responsible for the major portion of this drop, since a significant linear regression in brood size with advancing age has been demonstrated on the area (Kozicky, 1951).

A similar comparison between the September and October means (No. 1 dew mean eliminated because only one count in October) showed a 25 per cent increase in October. Cover changes were quite extensive in October since all of the soybean crop and half the corn crop was harvested and a killing frost occurred early in the month. These

changes would tend to greatly increase visibility and result in higher counts. Another possible reason was the opening of the Minnesota hunting season on October 25 with a resultant influx of birds into Iowa. Such an influx could be reflected in the counts; in fact an approximate 50 per cent increase was noted after that date. Nearly half of Route 1 was on the state boundary line and about a third of Route 2 was only one mile away.

An attempt was made to devise a substitute for the Duvdevani Dew Gage which would be inexpensive, easily made, and accurate. After testing several paints, three were found which did not differ statistically from the standard gage. Two were of a type of "flat" wall finish. On the basis of all tests, a block of knot-free, No. 2 white pine painted with two coats of enamel undercoat was found to be most suitable. Because such blocks tend to deteriorate with use and age, it would appear advisable to check them against the standard gage each year before use and make new ones if necessary. If the blocks were made in exactly the same manner year after year, the error due to variation from the standard would be quite small. Even with this possible error present, the optical method of dew measurement would enable adjustments to a constant dewfall to be made.

SUMMARY

1. The purpose of this study was to determine, in a quantitative manner, the effects of the physical factors which affected the fall roadside pheasant census in Iowa in order to decrease the size of sample necessary to predict population changes at specified probability levels or to increase the accuracy of the present method.

2. The investigation was centered about the Winnebago Pheasant Research Area in north-central Iowa, an area with level to gently rolling topography, 95 per cent of which is under cultivation.

3. Two 30-mile routes were run alternately at a rate of 12 miles per hour, beginning at sunrise, from August 1 to October 31. Complete weather data were gathered before and after the census. The Duvdevani optical method of dew measurement was used.

4. Rain falling during and/or before the census resulted in wide variation in the counts. Fog resulted in counts significantly lower than would be expected under similar conditions with fog absent. Wind direction and actual barometric pressure had no discernible effect. Censuses made when frost was present were deleted because of difficulty in comparing qualitative frost measurements with other counts.

5. Multiple linear regression analysis was made of the relationship of dew, wind velocity, relative humidity, cloudiness, temperature, and rate of pressure change to the number of pheasants observed per mile on each route. The coefficient of multiple correlation was 0.969 on Route 1 and 0.930 on Route 2, both of which were significant at the 0.01 probability level. R^2 values indicated that 93.8 and 86.5 per cent of the variation on Route 1 and Route 2, respectively, were due to the influence of climatological factors.

6. Application of the t-test to each factor individually showed that only the dew and the temperature effects on Route 1 and the dew effect on Route 2 were significant. Further comparisons showed that the simple linear regression of birds per mile on dew was nearly as good as the multiple regression for purposes of making adjustments in the population estimates.

7. The six weather factors were found to exert equal effects on both routes. All factors but cloudiness were found to be significantly correlated to the numbers of birds observed per mile when the simple linear regression and correlation coefficient were determined for each factor separately. However, no allowances for inter-relationships among the factors was made by such analyses.

8. The time of day was found to have a significant linear effect at the 0.01 probability level. Starting the counts at the same time with respect to sunrise alleviated the necessity for making corrections for this effect.

9. There was less variation in counts made in August than in those in September or October. Considering all factors, August appeared to be the optimum time for conducting the roadside census in Iowa.

10. A substitute was devised for the standard Duvdevani dew gage in the form of a block of knot-free, No. 2 white pine painted with two coats of enamel undercoat. Such blocks should be checked thoroughly against a standard block each year before use and replaced if necessary.

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SPRING FOOD HABITS OF SURFACE-FEEDING DUCKS IN MAINE[1]

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Autumn and early winter food habits of many species of ducks are reasonably well known, but there has been little opportunity to study their food habits at other seasons. Generally it is not feasible to make extensive collections prior to or during the breeding season. However, because of mortality to waterfowl during muskrat trapping (Gashwiler, 1949), the Maine Cooperative Wildlife Research Unit has received several ducks each spring after they were killed in muskrat sets. The purpose of this report is to summarize the results of examination of food contents of 72 stomachs (gizzard and gullet) taken in early spring.

Materials and Methods

A total of 113 stomachs was available for examination, but forty-one contained an insufficient quantity of food for tabulation. The 72 specimens used for this report include 39 wood ducks (*Aix sponsa*), 20 black ducks (*Anas rubripes*), 12 green-winged teal (*Anas carolinensis*), and one blue-winged teal (*Anas discors*). All specimens were collected between March 27 and May 3.

Stomach contents were washed, screened, separated and measured to the nearest tenth of a cubic centimeter. Tabulation of food materials is by the "percentage-by-bulk" method as practiced by the U. S. Fish and Wildlife Service. This method was used since it has been employed often in waterfowl food habits studies and thereby permits more direct comparison. But, like any system of recording food habits data, this method has disadvantages The principal source of error occurs when a few specimens contain large quantities of a single food item. Such instances are discussed in the text. Data from collected specimens are supplemented by information gathered from direct observation in the field on several areas from which specimens were obtained.

All ducks used in this study were taken in fresh-water areas from seven counties in the coastal and intermediate upland sections of Maine. Most of them were taken in the Penobscot and St. Croix River watersheds. The areas of collection may be classified as either sedge - meadow marshes or wooded streams.

The sedge-meadows are usually poorly drained, acid marshes containing proportionately large expanses of sedge (*Carex* spp., but especially *Carex lasiocarpa* var. *Americana* and *Carex rostrata*) often growing in floating mats. These areas typically support growths of sweet gale (*Myrica gale*), leatherleaf, (*Chamaedaphne calyculata*), holly (*Ilex verticil-*

[1] Contribution from Maine Cooperative Wildlife Research Unit, University of Maine, Orono, Maine; Maine Department of Inland Fisheries and Game, University of Maine, Wildlife Management Institute, and U. S. Fish and Wildlife Service, cooperating. Appreciation is expressed to Howard L. Mendall for assistance in analyzing the stomachs and reviewing the manuscript; to the several graduate assistants who helped to examine the food materials; to staff members of the Department of Botany and the Department of Zoology, University of Maine for assistance in identifying some of the food items.

lata), and other shrubs as associate species with the sedges. The water channels throughout the sedge-meadows commonly contain spike-rushes (*Eleocharis* spp.), pickerel weed (*Pontederia cordata*), pondweeds (*Potamogeton* spp.), burreeds (*Sparganium* spp.), waterlilies (*Nuphar* spp.), and water bulrush (*Scirpus subterminalis*). This is a common type of habitat in Maine and is heavily utilized by waterfowl during spring migration and nesting seasons.

The wooded streams are characterized by slow to moderate currents with scattered growths of aquatic plants. Shallow coves, or in some cases, narrow belts along the shores, contain beds of pickerel weed, pondweeds, burreeds, sedges and spike-rushes. Water bulrush and some species of pondweeds are frequently present in the deeper channels, but often do not fruit abundantly in these sites. The shores support dense growths of ferns, shrubs, and trees with red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), elm (*Ulnus americana*), willows (*Salix* spp.), and alder (*Alnus rugosa*) predominating.

High water levels are prevalent at these areas in the spring. Inundation of wooded flood plains or sedge-meadows is normal during and after the break-up of ice in late March and April.

RESULTS

The results of the stomach analyses are tabulated in Tables 1, 2 and 3. In each group of birds the sedges and burreeds were found in large quantities and comprised one-half to two-thirds of the foods eaten. Although 15 genera of sedges are represented, only the genus *Carex* formed an appreciable portion of the diet. Almost all of the material consisted of seeds. In addition to making up from one-fifth to over one-half of the diet of each group of birds, seeds of this genus occurred in 70 per cent of the gizzards. Mendall (1949) reported that sedge seeds formed 26 per cent of the spring food of 31 black ducks taken in Maine. He further points out that because of high water levels, black ducks are forced to do much of their feeding over flooded sedge-meadows. Field observations suggest that this is even more prevalent in teal and wood ducks—they

TABLE 1.—SPRING FOOD OF WOOD DUCKS (39 STOMACHS)

VEGETABLE FOOD	Percentage of Total	Percentage of Total
Cyperaceae		36.4
Sedge (*Carex* spp.)	28.5	
Common spikerush (*Eleocharis palustris*)	2.7	
Water bulrush (*Scirpus subterminalis*)	2.0	
Woolgrass (*Scirpus cyperinus*)	1.9	
Torrey's three-square (*Scirpus torreyi*)	1.3	
Sparganiaceae		35.7
Burreed (*Sparganium* spp.)	35.7	
Rosaceae		4.3
Wild rose (*Rosa* spp.)	4.3	
Cornaceae		2.0
Dogwood (*Cornus* spp.)	2.0	
Hydrocharitaceae		2.0
Wild celery (*Vallisneria spiralis*)	2.0	
Alismaceae		1.0
Arrowhead (*Sagittaria cuneata*)	1.0	
Miscellaneous Plant Food[1]		2.3
Unidentified Plant Food		7.1
Total Plant Food		90.8
ANIMAL FOOD		
Insecta		9.2
May-flies (Ephemeridae), Beetles (Coleoptera), Flies (Diptera), Tree-hoppers (Membracidae), Grasshoppers (Orthoptera), Stone-flies (Plecoptera), Whirligig-beetles (Gyrinidae), Water-striders (Gerridae), Moths (Lepidoptera)		
Total Animal Food		9.2

[1] Bulrush (*Scirpus smithii*), Dulichium (*Dulichium arundinaceum*), Spikerush (*Eleocharis* spp.), Cyperus (*Cyperus* spp.), Bulrush (*Scirpus* spp.), Arrowhead (*Sagittaria latifolia*), Cutgrass (*Leersia* spp.), Miscellaneous grasses, Floatingleaf pondweed (*Potamogeton natans*), Witch-hazel (*Hamamelis virginiana*), Pickerelweed (*Pontederia cordata*), Mermaidweed (*Proserpinaca palustris*), Smartweed (*Polygonum* spp.), Mustard (*Brassica* spp.), Birch (*Betula* spp.), Cranberry (*Vaccinium* spp.).

apparently prefer more shallow water than do the black ducks. This is reflected in the higher proportion of sedges found in the stomachs of teal and wood ducks.

An interesting point in connection with the high utilization of the sedges in the genus *Carex* is that the species common in waterfowl marshes do not often retain quantities of seed through the winter. However, these achenes are usually deposited upon a mat of closely interwoven roots and a layer of partially decayed organic material. Since little water action is present under most conditions in stands of *Carex*, the seeds remain readily available. In contrast, the fruits of other species may be dropped in sites where currents, siltation, or the accumulation of large amounts of dying vegetation may deposit a rather heavy layer of material over the seeds.

Burreeds did not make up as much in bulk as the sedges, but they occurred in 73 per cent of the stomachs—usually as

TABLE 2.—SPRING FOOD OF BLACK DUCKS (21 STOMACHS)

VEGETABLE FOOD	Percentage of Total	Percentage of Total
Cyperaceae		25.8
Sedge (*Carex* spp.)	22.4	
Cladium (*Cladium mariscoides*)	2.6	
Torrey's three-square (*Scirpus torreyi*)	.8	
Sparganiaceae		22.8
Burreed (*Sparganium* spp.)	22.8	
Najadaceae		8.2
Floatingleaf pondweed (*Potamogeton natans*)	4.1	
Pondweed (*Potamogeton* spp.)	4.1	
Gramineae		7.2
Domestic oats (*Avena sativa*)	4.7	
Rice cutgrass (*Leersia oryzoides*)	.7	
Miscellaneous grasses	1.8	
Haloragidaceae		1.7
Mermaidweed (*Proserpinaca palustris*)	1.7	
Cornaceae		1.5
Dogwood (*Cornus* spp.)	1.5	
Polygonaceae		1.1
Largeseed smartweed (*Polygonum pennsylvanicum*)	1.1	
Miscellaneous Plant Food [1]		2.7
Unidentified Plant Food		19.0
Total Plant Food		90.0
ANIMAL FOOD		
Insecta		6.0
Miscellaneous insects	5.8	
Beetles (Coleoptera)	.2	
Mollusca		4.0
Pelecypoda		
Pill clam (*Pisidium* spp.)	2.6	
Miscellaneous bivalves	.3	
Gastropoda		
Miscellaneous snails	1.1	
Total Animal Food		10.0

[1] Common spikerush (*Eleocharis palustris*), Spikerush (*Eleocharis* spp.), Dulichium (*Dulichium arundinaceum*), Smartweed (*Polygonum* spp.), Birch (*Betula* spp.), Wild cherry (*Prunus* spp.), Wild rose (*Rosa* spp.), Bramble (*Rubus* spp.), Mountain holly (*Nemopanthus mucronata*), Bedstraw (*Galium* spp.), White pine (*Pinus strobus*).

TABLE 3.—SPRING FOOD OF TEAL (STOMACHS OF 12 GREEN-WINGED AND ONE BLUE-WINGED TEAL)

VEGETABLE FOOD	Percentage of Total	Percentage of Total
Cyperaceae		63.4
Sedges (*Carex* spp.)	55.6	
Sedge (*Carex crinita*)	4.7	
Bulrush (*Scirpus* spp.)	1.6	
Spikerush (*Eleocharis palustris*)	1.5	
Polygonaceae		8.2
Waterpepper (*Polygonum hydropiper*)	7.8	
Largeseed smartweed (*Polygonum pennsylvanicum*)	.4	
Sparganiaceae		6.4
Burreed (*Sparganium* spp.)	6.4	
Najadaceae		7.2
Pondweed (*Potamogeton pusillus*)	5.6	
Pondweed (*Potamogeton* spp.)	1.6	
Miscellaneous Plant Food		8.7
Alder (*Alnus rugosa*)	2.1	
Bogbean (*Menyanthes trifoliata*)	1.3	
Rice cutgrass (*Leersia oryzoides*)	.3	
Bramble (*Rubus* spp.)	.3	
Unidentified vegetable food	4.7	
Total Plant Food		93.9
ANIMAL FOOD		
Annelida		5.0
Earthworms	5.0	
Insecta		.9
Moths (Lepidoptera)	.6	
Beetles (Coleoptera)	.3	
Mollusca		.2
Miscellaneous mollusca	.2	
Total Animal Food		6.1

seeds. Fruits of burreeds soon lose their specific identity after being subjected to the grinding action of a gizzard. However, the analysis showed that much of this material was from two species. The most common was *Sparganium minimum*, a small plant that characteristically grows in very shallow water. In Maine it is often found growing on floating sedge-meadows in sites that are only moist during mid- and late summer. The other species, *Sparganium chlorocarpum* grows as an emergent, also in shallow water. Because of their habit of growth both species are probably more accessible to surface feeding ducks during higher water levels. In addition, these burreeds generally retain their seeds over winter. Even in May and early June the bur-like clusters of seeds of the previous year remain rather firmly attached to some plants. This fact undoubtedly makes them more available to ducks in the spring.

The pondweeds as a group are ordinarily considered to be among the most important duck foods (Martin and Uhler, 1939). In Maine, these plants are of some value as spring food, but the low incidence of pondweeds in contrast to some other plants, is again considered the direct result of availability. During early fall when low water conditions are common, large flocks of migrant ducks feed heavily in beds of pondweeds. In the spring these beds are too deeply submersed in most areas for surface feeding ducks to obtain the scattered fruits that remain. Table 1 indicates that pondweeds made up about eight per cent of the black duck food, but this is due to one stomach which contained a large proportion of *Potamogeton natans*. Actually stomachs of only four black ducks contained any trace of pondweeds. The same situation was found with teal where only three birds had fed on pondweeds, but one had eaten a large quantity of seeds of *Potamogeton pusillus*.

Small amounts of many other plants were recorded. Of interest is the occurrence of several terrestrial or semi-terrestrial species. Examples of these are alder, cherry, witch hazel, dogwood, wild rose, bramble and grasses. Plants in this category were found 31 times. They are suggestive of feeding along the temporarily flooded margins of waterways. Based upon field observations it is somewhat surprising that more of the food did not consist of these kinds of plants.

The highest proportion of unidentified food was in the black duck stomachs. Probably these larger birds remain alive for a longer period in muskrat traps, which would result in more complete digestion of the food materials already present. More of their gizzard contents were ground to the point where accurate identification was questionable. In many instances this finely ground material was mixed with other larger fragments that could be identified. It often appeared that the more completely ground food was of the same species as those particles of food that were still partially intact. However, unless identification was certain this material was listed as unknown.

No single species was predominant among animal foods. In view of the fact that the ducks were killed during and shortly after the spring break-up of ice it is interesting that this type of food was found in 36 per cent of the stomachs; most of it was insect larvae. But, as a whole, animal life did not appear to be important.

The stomachs available for this study were limited, but do suggest trends in food habits that vary from the fall pat-

tern. It is hoped that other investigators may be able to collect spring specimens from trappers or from other sources to present further data on spring food habits. A more complete understanding of foods available and eaten during this critical period seems desirable, especially in view of the fact that much emphasis is currently being placed upon marsh management for waterfowl.

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A METHOD FOR OBTAINING SAGE GROUSE AGE AND SEX RATIOS FROM WINGS [1]

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The importance of age and sex ratio data from a population is well known. Obtaining this information for sage grouse during hunting seasons has been dependent upon experienced personnel examining the birds. Patterson (1952) lists several methods for sexing juveniles (size of head, tarsus, middle toe, and comparative body size) and aging the entire sample (mandible test, ossification of sternum, comparative toe coloration, comparative body weights and retention or molting of the first two primaries). He further states that "with the experience gained from handling thousands of birds during live-trapping operations, it was possible to determine age and sex of immature birds with a very high degree of accuracy." It is the purpose of this study to provide a method for obtaining large samples of sex and age ratios from wings gathered by inexperienced personnel.

PROCEDURE

Wings were collected on October 4th, 1953, at checking stations operated in the eastern half of Montana. Those from birds of known sex (examination of the gonads) and/or age (measurement of the bursa of Fabricius) were placed in separate sacks.

Within two weeks, before the wings had dried appreciably, measurements were made by placing the end of a ruler against the trailing edge of the wing behind the feather to be measured. The feather was flattened against the ruler, and length read to the nearest millimeter.

In recording the measurements, distinction was made for those feathers not molted (post-nuptial molt in mature birds, post-juvenile in immature) and notations made as to whether unmolted feathers appeared as juvenile or adult.

[1] Contribution from the Wildlife Restoration Division, Project 38-R, Montana Fish and Game Department.

The writer wishes to thank Dr. Bernard Ostle, Montana State College, for statistical treatment of the data and Dr. Don C. Quimby, Montana State College, for critically reading the manuscript.

The primaries were numbered from distal to proximal.

The measurements of primaries obtained from each wing of birds of known sex were placed in one of the following groups with sexes kept separate within each group: (A) Primary 1 not molted or all molted; (B) Primaries 1 and 2 not molted; (C) Primaries 1, 2, and 3 not molted; (D) Primaries 1, 2, 3, and 4 not molted. Primary measurements obtained from birds of known age were arranged into the same categories but were separated as to juvenile or adult within each group.

RESULTS AND DISCUSSION

SEX DETERMINATION.—Sex determination is dependent upon the variation in length of individual primaries in different stages of molt. Baker (1953) attempted to sex prairie chickens by the difference in length of Primaries 7 and 8 (numbers assigned from proximal to distal). Although he found a difference between sexes, he concluded that it was not great enough to provide a means of distinguishing between them.

From wings where both sex and age were known, primary measurements from adults were compared with those from juveniles of the same sex and molt stage. Although a slightly higher mean was found for the adult measurements, a very high degree of overlap occurred in the ranges of the two. As a result, measurements from all birds of known sex, both juveniles and adults, were included in the sex determination data. The ranges of measurements are given graphically by sexes for each group in Figures 1 to 4. The lower ranges of newly molted primaries are not included.

A dividing line was established between the male and female measurements of those primaries in each molt stage which appeared least likely to overlap. This dividing line was established by adding the mean lengths of the individual primary of the two sexes and dividing the sum by two. In using this method, measurements from these primaries falling above the line are classed as males, those below, as females. The probability of misclassification for this method was computed for each of the key primaries based on the sample size available in each group (Figures 1 to 4).

Group A (Figure 1) includes those wings with all molted or No. 1 not molted. These two molt stages were incorporated because of the similarity in the primaries of greatest use for sex determination. Measurements for Primary 1 in this category were not included in the graph as the range would be too great (including newly molted and those not molted) to be of any value to this method. For birds falling into this group, Primary 4, 5, or 6 appears to be most valid for determining sex, with the probabilities of misclassification being .0001, .0003 and .0002, respectively.

Measurements from wings falling into group B (Figure 2) suggest Primary 1 or 6 as being the more sound for use in determining sex. The probability of misclassification for 1 and 6, is .0013 and .0037, respectively.

Data in group C (Figure 3) indicate Primaries 1 and 2 as being of greatest use in determining sex, the probability of misclassification for Primary 1 being .0040 and for 2, .0078.

Group D (Figure 4), although based on a very meager sample, was included for comparison with Group C. As in the latter group, Primaries 1 and 2 appear more valid for use with this method. The measurements from each primary except No. 5, from the one male available in this group are designated by shaded triangles. Primary 5 fell below

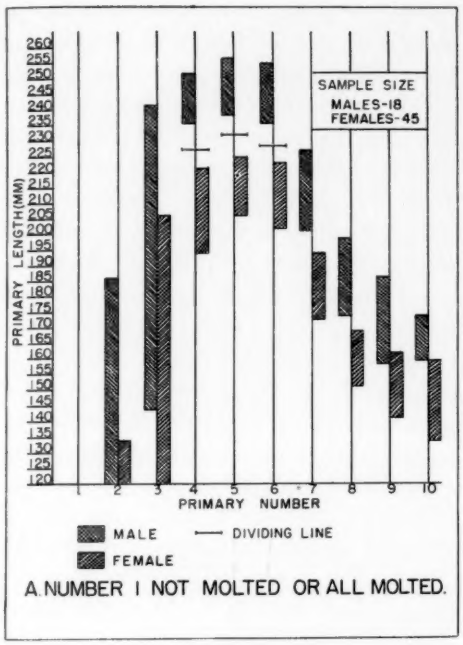

FIG. 1

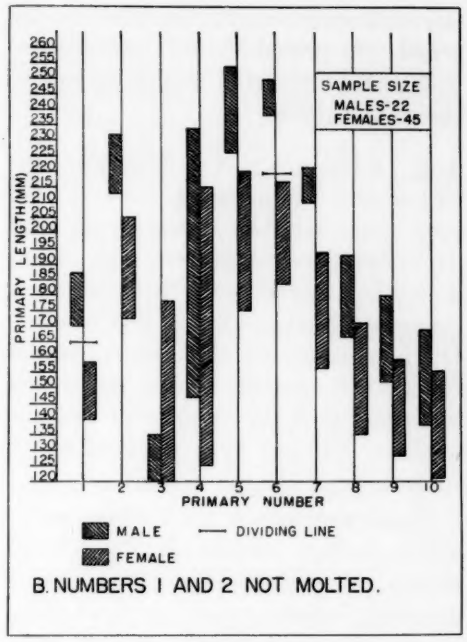

FIG. 2

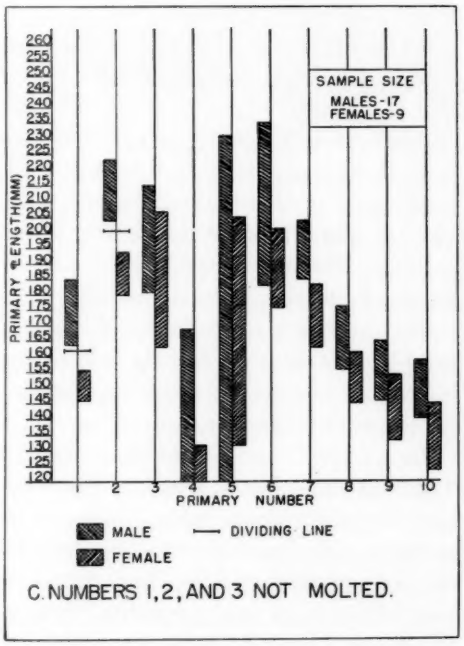

FIG. 3

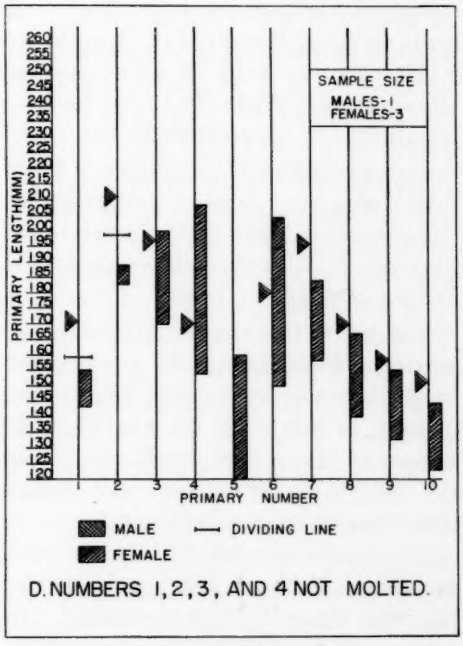

FIG. 4

FIGURES 1 TO 4. **Range of measurements of sage grouse primaries with dividing lines indicated on key primaries for classifying male and female.**

the minimum length included in the graph. No probability of misclassification was computed in this group due to the small sample.

AGE DETERMINATION.—Patterson (*op. cit.*) states: "In common with at least some other members of the grouse family, notably ruffed grouse, sage grouse do not customarily molt their two outer primaries throughout their first winter." He further stated that the bursa of Fabricius is normally present in juvenile birds but that the validity of this age indicator had not been followed in his study beyond the fall season.

These statements are further established from a sample of twenty sage grouse collected by the writer during January, February and March of 1953. Eleven possessed bursae ranging from 10 to 17 millimeters. The remaining nine had bursae with a maximum depth of 2 millimeters or had none at all. The eleven birds retained juvenile Primaries 1 and 2 in both wings while the nine possessed all adult primaries. The pointed and frayed tips of juvenile Primaries 1 and 2 as compared to rounded tips of those found on adults were very apparent in this sample of birds. This condition was also described for sharp-tailed grouse by Wright and Hiatt (1943).

The use of this character as such (retention of Primaries 1 and 2 in juveniles), is dependent upon the molt having progressed to this stage by the time the sample is taken. Despite the fact that the 1953 hunting season was opened later than customary in Montana, many adult females had not progressed to this molt stage and were found to be retaining two, three, or four primaries. The adult males available for examination, with the exception of one, had molted all primaries, but only recently as determined by those last replaced. A small sample of adult males trapped and examined two weeks before the season still possessed one or two unmolted primaries. Weekly collections made throughout the breeding season suggest an association of the beginning of the post-nuptial molt with the cessation of breeding activities (strutting ground behavior for males and nesting duties for females), which may explain the relatively short span in molt stages found in adult males as compared with the wide variance in adult females. A similar condition for pheasants has been described by Kabat, *et al.* (1950), and for male prairie chickens by Baker (*op. cit.*).

Those birds with all primaries molted or with Primary 1 not molted (Group A) are classed as adults. For birds still retaining two or more primaries, a difference is noticeable between the primaries of adults which have been carried a year and the primaries of juveniles. Birds with Primaries 1 and 2 not molted (Group B) are recognized primarily on the condition of these two feathers. The tips of Primaries 1 and 2 on adults may show some sign of wear, but usually still possess a more rounded tip (especially noticeable in Primary 2) contrasting to the more pointed tips of juvenile feathers. This character is illustrated in Figure 5. Adults, especially males, generally possess a more uniformly faded, gray-brown color on the unmolted primaries in contrast to the more mottled color found in juveniles.

In groups C and D, where Primaries 1, 2, and 3 and 1, 2, 3, and 4 respectively are not molted, an aging character is noted in addition to recognizing juvenile or adult primaries. This character is in the difference in measurements between Primaries 2 and 3. With all adults examined, Primary 3 was greater in length than 2, whereas in all juveniles, 3 was less than 2. This is shown along with

FIG. 5. Juvenile and adult female sage grouse wings showing condition of tips of unmolted primaries 1 and 2 (juvenile above, adult below).

bursa measurements from these birds in Table 1. The condition of the tips of the non-molted primaries may be used in these stages for verification of age on wings which may have one of the key feathers broken.

Application of this method provided the following comparison. Of the 247 birds examined to provide the original known sex and age data, 160 were sexed and 87 were aged. Sex and age ratios from this sample were 1 male : 2.1 females and 1 adult : 1.5 juveniles. From these same areas wings were collected from 195 birds which for lack of time or

TABLE 1.—OBSERVED DIFFERENCES BETWEEN LENGTHS OF PRIMARIES 2 AND 3 AND BURSA MEASUREMENTS FROM ADULT AND JUVENILE BIRDS. (MEASUREMENTS TAKEN FROM BIRDS WITH PRIMARIES 1, 2, AND 3 OR 1, 2, 3, AND 4 NOT MOLTED.)

	Difference in Length (mm) from Primary Number 2 to 3		Bursa Depth (mm)	
	Adult	Juvenile	Adult	Juvenile
Maximum	24	−27	7	25
Minimum	11	− 4	0	13
Average	17.3	−12.3	1.6	18.9
Sample Size	13	20	13	19

due to the condition of the bird were neither sexed nor aged. Using the method described, sex and age ratios obtained from this group of wings were 1 : 1.8 and 1 : 1.2 respectively. The similarity in these two sets of ratios suggest the merit of this procedure.

SUMMARY

Wings from 247 sage grouse of known sex and/or age were collected during the opening day of the 1953 grouse season in Montana. The primary measurements obtained from wings of birds of known sex were placed into one of four molt stages with the sexes kept separate within each group. Primary measurements from birds of known age were placed into similar categories but were separated as to juveniles or adults.

Sex determination was accomplished by an established difference in length of individual primaries in different stages of molt.

Age determination was based upon the presence or absence of juvenile Primaries 1 and 2, condition of Primaries 1 and 2, or the difference in length between Pri-

maries 2 and 3, depending upon the stage of molt.

Sex and age ratios obtained by use of this method show similarity to ratios from a group of known sex and age birds from the same areas.

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MISSOURI'S PROGRAM OF EXTENSION PREDATOR CONTROL [1]

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Missouri, like many states, has long had to cope with complaints of damage to livestock and poultry caused by predatory wild animals, mainly foxes and coyotes. Warfare was legislated against wolves, coyotes, and bobcats as early as 1825 in allowing counties to pay bounties on these animals, with more or less aid from legislative grants. Custom and tradition have caused bounty payments to be maintained. Paradoxically, the tradition of fox chasing in Missouri has so far largely kept tax money from being wasted on a bounty for foxes.

The bounty did not stifle farm damage complaints, and between 1923 and 1946, the U. S. Fish and Wildlife Service "government trapper" system was added. It was given three good trials, through about 14 years, with from one to nine government trappers operating annually. Farmers still were not satisfied, and a state hunter with dogs was tried during 1944 and 1945 to reach the many complainers that the government trappers could not get to quickly enough. For various reasons, including costs, delays, and failure to reduce damage for enough farmers, the complaints continued and both of these programs were abandoned. The bounty system was retained, and the present extension predator control program shows no tendency to supplant the bounty.

Poisons and explosive or chemical devices, popular methods of predator control in parts of western United States (Young and Jackson, 1951), may not be used legally in Missouri. Aside from the legal prohibition, Missouri's relatively dense population of dogs, livestock, and

[1] The development and application of simplified trapping techniques by the Missouri Conservation Commission's extension trappers, Lewis J. McIntosh and Robert H. Smith, has been a major contribution in carrying out this program. Cooperation of the U. S. Fish and Wildlife Service was instrumental in the initial organization of the program. Acknowledgment is made to Pittman-Robertson Project 13-R Missouri for time spent by the senior author in manuscript preparation. A brief account of the program was presented by the senior author at the 15th Midwest Wildlife Conference, Chicago, Ill., December 9–11, 1953.

humans renders the use of such methods too hazardous to be practicable.

In 1945, the present program of extension predator control was initiated. This program made use of the farmer as the direct predator control agent. In some respects, it was a development of certain aspects of the former government-trapper system. The most successful government trappers were those who responded most promptly to calls from farmers; such men usually found the predators present and active. Promptness was not possible when one man undertook to do all the trapping but, by working closely with the farmer, the trapper could often establish a workable trapline in a day or two, showing the farmer how to locate good trapping sites and make good sets. The trapper could then move to other damage areas and repeat the process. Often upon his return to the first area the farmer had made a catch; if not, he usually knew where the animals were ranging, and this saved the trapper time in helping the farmer relocate the traps.

This procedure showed that farmers could learn how to trap as easily as learning other farm jobs, and that concentration of trapping in a damage area was the most practical way of catching the individual animals actually doing the killing. This led to the idea of helping farmers to help themselves, which is the root of the extension trapping program as it is of all agricultural extension services.

ORGANIZATION AND OPERATION

Extension predator control was started in Missouri in September 1945, when one extension trapping instructor was employed by the Missouri Conservation Commission and the U. S. Fish and Wildlife Service, with supervision by the latter agency. A second extension trapping instructor was added in February 1947, and both men have been employed steadily since. The Missouri Conservation Commission assumed supervision of the program in July 1947, and all costs in July 1951.

One extension trapper operates mainly in the northern half of Missouri, the other in the southern half. Supervision and scheduling are handled in the Conservation Commission's Game Section. Both extension trappers were formerly U. S. Fish and Wildlife Service trappers and, with their background of farm experience, are able to demonstrate trapping techniques in a way that is accepted by farmers. Their ability to discuss predation and other wildlife relationships, in terms that reflect farmers' thinking, has contributed importantly to the friendly reception accorded the program.

At the outset of the program a working agreement was arranged with the Missouri Agricultural Extension Service so that agricultural extension agents might act as local clearing houses for requests from farm groups for predator control assistance. This also helped to establish the program as essentially a service for farmers, furnished by the State's wildlife agency in recognition of an opportunity to cooperate with landowners.

County agricultural extension agents usually organize requests from interested farm groups. They arrange with the Conservation Commission's predator control supervisor for local training on a scheduled date, and announce meetings and demonstrations. The activities of the extension trappers may be integrated with other local agricultural projects, if desired. Occasionally, individual farmers or field personnel of the Conservation Commission may initiate requests, sometimes directly to extension trappers.

The extension trapper usually is assigned to work for one week in the county or locality requesting assistance. Depending upon the amount of interest and the local damage situation, the county agricultural agent may provide for a general meeting in his county scheduled early in the week. Attendance at these meetings runs from a handful to 100 or more people. If only a few farmers are affected, the meeting is combined with the field demonstration. Where a preliminary meeting is held, a fairly comprehensive coverage of essential information is presented by the extension trapper. During such a meeting, arrangements are made to conduct a series of trapping demonstrations for smaller groups during the remainder of the week, preferably on farms where predators are currently active. Each field demonstration may require from one-half day to two or three days, depending upon local conditions. Field work may be conducted with one man; in some cases, 25 to 30 have participated.

Material covered only briefly in meetings is demonstrated in detail in the field. Trapping techniques are shorn of old superstitions and are simplified to essential requirements to fit in with the pace of modern farming. The farmers make most of the trap sets themselves, under the direction of the extension trappers. If predators are active, the traps are left set and a catch may be made by at least one farmer during the week—sometimes the first night. About one farmer in seven may have difficulty in getting traps located effectively. All such farmers are given further assistance when they request it.

Whether a meeting is held or only field trapping is conducted, the extension trapper emphasizes subject matter of most timely local interest, along with necessary information and techniques, as follows:

1. Purpose of the program; sponsoring agencies.
2. Explanation of normal beneficial predation, as distinguished from livestock and poultry losses caused by individual predators.
3. Characteristics and life history of coyotes and foxes essential to successful trapping for damage reduction.
4. Trapping as the most practical and dependable method for Missouri farmers to use.
5. Trapping equipment required and where obtainable.
6. Selecting good trap locations and how to interpret various kinds of animal sign to accomplish this.
7. How to make effective trap sets.
8. Variations in trap sets for coyotes and foxes.
9. Trapping parents and pups during the denning and rearing season.
10. Winter and frozen ground trap sets.
11. Use of various types of scent, manufactured and home-made.
12. Precautions to be followed in farm trapping for the least harm to beneficial wildlife and dogs and to maintain the goodwill of neighbors.

Requests for trapping instructions have come from an average of about 50 counties per year, requiring around 80 meetings and series of demonstrations (Table 1). All counties requesting extension trapper service have received it, usually within two weeks. Promptness of response is essential if the public is to be satisfied. Under the former government trapper system, a county often had to wait several months, if indeed it received assistance at all. Actually, only 43 per cent of the counties requesting government trapper service ever re-

ceived it, because the few trappers, doing all the work themselves, could visit only a fraction of the areas from which complaints were received. Also, some counties were reluctant to relinquish a government trapper once he was assigned, and others would complain of costs and ineffectiveness (Sampson and Bennitt, 1947–48). Prompt and effective action under the extension program has reduced the number of complaints received by the Conservation Commission almost to zero.

During the past eight years nearly 16,000 farmers and other interested people in most parts of the State have attended some 635 meetings. Following the meetings, training in the field has been received by more than 5,800 men (and a few women), mostly farmers. Thus, nearly two-thirds of the people actively interested in the predator damage problem, and who constitute a potential source of complaints, have been satisfied merely by attending a meeting where they can acquire a fuller understanding of what predation really is and what is required to reduce farm damage. Of the 5,800 taking field trapping instruction, a majority used their training at some time, and 873 received individual follow-up training on their farms in order to achieve satisfactory damage reduction.

Each of the two extension trappers is equipped with a 16-mm. sound movie projector, a 2″ x 2″ slide projector, projection screen, and a 35-mm. camera. This allows the use of movies and slides on predator habits and control methods, and adds considerable interest to rural meetings. A 15-minute sound and color movie, "Wolf Medicine," produced by the Missouri Conservation Commission in 1949, depicts coyote habits and methods of trapping them. The extension trappers have used the cameras to build up two collections of about 80 color slides each, which cover a fair share of the questions brought up by farmers. These are particularly useful in illustrating techniques when weather or seasonal conditions make field demonstrations impossible. The Conservation Commission's illustrated 20-page bulletin, "Controlling Coyote and Fox Damage on the Farm," by Sampson and Nagel (1948), explains many of the techniques;

TABLE 1.—EXTENSION PREDATOR CONTROL ACTIVITIES

Fiscal Year	No. of Counties Requesting & Receiving Service	No. of Demonstrational Meetings	Number of Farmers Participating			Predator Control Fund Trap Distribution	
			at Meetings	in Field Training	Follow-up Assistance	No. Farmers	No. Traps
1946	29	33	100	88	17	50	412
1947	43	78	650	421	50	129	554
1948	62	90	1,815	965	111	250	760
1949	53	94	1,781	908	140	205	676
1950	50	90	3,841	975	176	191	570
1951	54	81	2,243	815	157	208	668
1952	50	85	2,124	756	110	170	541
1953	48	84	3,158	874	112	158	548
Total	50 Annual Avg.	635	15,712	5,802	873	1,361	4,729

it is made available especially for those participating in the field training.

To provide suitable traps for immediate use, where farmers cannot purchase them locally, a supply of the No. 3-N Victor offset-jaw traps is made available at near cost through a revolving Predator Control Fund. This fund is sponsored by the Missouri Sheep and Wool Growers Association, which provided $200.00 to start the fund when the program was first begun. The treasurer of the Association handles all disbursements and deposits for the fund and, with his concurrence, the predator control supervisor acts as manager of the fund in ordering trapping supplies and making collections from farmers through the extension trappers. The extension trappers carry supplies of traps and drag-hooks with them, and sell them only at demonstrations. No shipments are made and no effort is made to sell traps; they are available only where needed and requested. The fund was allowed a small margin of profit in trap price. This permitted it to grow to a sufficient size (around $1,500.00 in recent years) to meet all obligations promptly, and eventually provided the much-needed cameras, film, and slide projectors.

The No. 3-N Victor offset-jaw trap was selected as the best all-around coyote and fox trap for a program of this type, and it is the only trap made available to farmers through the Predator Control Fund. In these offset-jaw traps the jaws do not completely meet and have round edges, providing less chance of broken bones, and therefore less chance of coyotes and foxes pulling or gnawing free. Experience indicates that if traps are tended daily, harmless animals (including dogs and livestock) usually can be released without permanent injury. The square-notch trigger and pan assembly of the Victor trap is more dependable in the hands of novices than the sharply beveled assembly of the more advanced Newhouse trap, partly because the more loosely built Victor mechanism is less likely to clog from rain-washed dirt or freezing moisture—an important consideration when traps may not be carefully located and set. Also, birds and rodents are not so likely to spring traps with square-notched triggers fully set. Somewhat less expensive stamped-steel traps are commonly purchased by farmers ordering traps from commercial sources. This is not at all objectionable, if the traps are large enough. The use of No. 3 or No. 4 traps is a definite factor in increasing trapping success, although for fox trapping size No. 2 traps (especially the No. 2 double coil spring traps) are generally satisfactory.

Adequate drag-hooks are preferred to solidly anchored trap stakes. Drag-hooks allow the trapped animal to drag the trap away, rather than to pull out of it, and trapping sites are seldom torn up and ruined for future trapping, as often happens with animals held in staked traps. The drag usually tangles in brush within a short distance of the trap location, and the drag-hook ordinarily leaves an obvious trail to the trapped animal. Drag-hooks made to our specifications (Figure 1) by local blacksmiths are attached to each pair of traps sold through the Predator Control Fund.

In the eight-year period the Predator Control Fund made available 4,729 traps to 1,361 farmers. This averaged 591 traps to 170 farmers per year. The service has been sufficient to get farmers started where the damage situation was acute and gave them time to order additional traps from mail-order firms or fur-houses.

Natural scent bait, a very high pri-

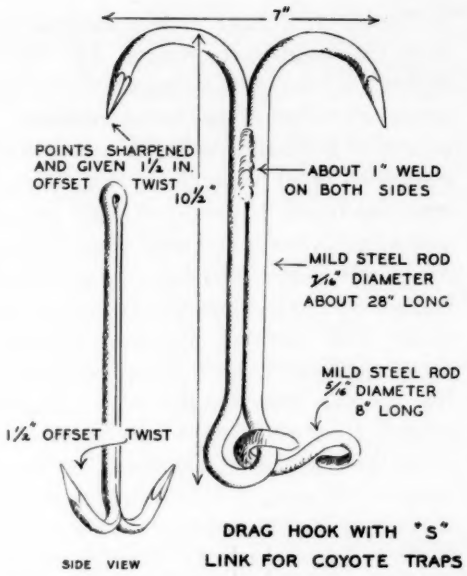
7"
POINTS SHARPENED AND GIVEN 1½ IN. OFFSET TWIST
10½"
ABOUT 1" WELD ON BOTH SIDES
MILD STEEL ROD 7/16" DIAMETER ABOUT 28" LONG
MILD STEEL ROD 5/16" DIAMETER 8" LONG
1½" OFFSET TWIST
SIDE VIEW
DRAG HOOK WITH "S" LINK FOR COYOTE TRAPS

FIG. 1. Specifications of a drag-hook that has proved large enough to be effective, yet sufficiently small to be easily buried beneath No. 3 steel traps for coyotes or foxes. (Drawing by Charles W. Schwartz)

ority item in demonstration and starting off farmers in trapping, is generally preferred by Missouri's extension trappers over fetid food baits and synthetic scents. This scent, usually composed of urine from mature coyotes, appears especially attractive to most adult coyotes and foxes among which the "killer" individuals are virtually always found. Fetid food scents seem somewhat more attractive than coyote urine scent to juvenile coyotes and foxes as well as to most of the other furbearers. One-half ounce bottles of natural scent were volunteered by the National Scent Company, Chilhowee, Missouri, and a bottle is given to each farmer who takes the field training and who plans to start trapping. Some farmers purchase more scent when needed; others collect it from caught animals.

The rural public is kept informed of the program through newspaper releases, farm magazines, and farm and wildlife radio and television programs. The extension trappers are often scheduled for demonstrations at Farm Day activities, 4-H Club and FFA summer camps, vocational agriculture classes, and exhibits at regional fairs and the State Fair.

The cost of operating the program, in 1953, was about $11,500. This includes salaries and expenses of the two extension trappers, and a prorated share of the supervisor's salary and expenses, only about one-fifth of his time currently being occupied by supervision of the program. Compared to annual coyote bounty payments running from $55,000 to $165,000 in recent years, the cost of the extension predator-control program seems small indeed.

RESULTS OF THE PROGRAM

Probably the most outstanding change noted since the extension program was begun has been the almost complete elimination of loud complaints for "somebody to do something" about foxes and coyotes killing poultry and livestock. Instead, this cry has been tempered to requests for training assistance. Most farmers seem to appreciate recognition that they can learn trapping for damage reduction as easily as learning how to spray for insect control, and they accept the challenge. Also it is human nature for most people to be far more satisfied with their own work than with a job done for them by someone else. Certainly they can realize that they are in the best position to apply immediate predator control on their farms whenever needed, and it makes sense to them for the State's wildlife agency to show them how to do it.

Occasionally a farmer who shows special interest and aptitude is recognized by his neighbors as possessing a little

more than usual ability in predator trapping, and they may call upon him to help them out on a "trade-work" basis. This principle has been carried further: in large communities farmers have formed associations of paying members and hired one of their number to do all the trapping during spring and fall months when most damage usually occurs and when trapping is most effective. This has generally worked out much better on a salary basis than on a "per predator" basis, because the former encourages trapping for damage reduction even where animals may be relatively scarce. The extension trappers have rendered valuable service through improving the efficiency of such local farm trappers, and in advising communities desiring a similar arrangement as to the best ways and means of accomplishing their purpose.

Annual mail surveys were made of persons who participated in field training. Over the eight years, an average of 24 per cent of the 7,806 farmers questioned furnished information. Tabulations are made only of the replies: no attempt is made to expand the sample.

The information received is tabulated in Tables 2, 3, and 4. We summarize here the eight-year picture. Of 1,877 replies, 1,114 (59%) reported 10,195 predator catches or an average of slightly over nine predators each. The catch was composed of 30 per cent coyotes, 53 per cent red foxes, 15 per cent gray foxes, and a few bobcats and wild dogs (Table 2). It was found that farmers who had learned to trap were not reluctant to apply their learning whenever damage threatened again. Also, when the offending animal was caught and damage ceased, they would take up their traps.

To the query of how many hours they spent in trapping, 1,110 farmers reported a total of 55,209 hours—or an average of 49.7 hours each. An average of 5.4 hours trap-tending was required to catch each predator (Table 3). The average time for coyotes alone was 17.8 hours per coyote. This is nearly three and one-third times as efficient as the government trappers, who averaged 60.3 hours per coyote catch over a ten-year period, between 1936 and 1946 (Sampson and Bennitt 1947–48). Since the population of coyotes has not changed enough to account for this difference, the increased efficiency is probably due mainly to the

TABLE 2.—PREDATOR CATCH REPORTED

Fiscal Year	No. of Farmers Reporting Catches	Number of Predators Trapped						Average Catch per Farmer
		Coyote	Red Fox	Gray Fox	Bob-cat	Wild Dog	Total	
1946	30	80	21	27	1	..	129	4.3
1947	114	473	526	157	9	9	1,174	10.3
1948	187	622	756	322	10	10	1,720	9.2
1949	243	682	1,118	301	17	6	2,124	8.7
1950	148	426	645	200	13	..	1,284	8.7
1951	128	329	597	168	10	2	1,106	8.6
1952	163	313	1,116	212	5	2	1,648	10.1
1953	101	174	665	168	1	2	1,010	10.0
Total	1,114	3,099	5,444	1,555	66	31	10,195	9.2 Avg.

TABLE 3.—TRAPPING TIME REPORTED AND HOURS PER PREDATOR

Fiscal Year	No. Farmers Reporting Trapping Time	No. of Trapping Hours		Total Predators Trapped	Average No. Trapping Hours per Predator
		Total Hours Reported	Average per Farmer		
1946	30	1,973	65.8	129	15.3
1947	120	7,233	60.3	1,174	6.2
1948	189	11,083	58.6	1,720	6.4
1949	248	15,417	62.2	2,124	7.3
1950	143	6,008	42.0	1,284	4.7
1951	134	3,812	28.4	1,106	3.4
1952	144	5,939	41.2	1,648	3.6
1953	102	3,744	36.7	1,010	3.7
Total	1,110	55,209	49.7	10,195	5.4

fact that farmers do not need to spend time traveling to the trapping area and generally have a pretty good idea as to where the animals are ranging.

In order to learn how much actual damage reduction farmers thought they were accomplishing for themselves, they were asked to report their losses for the year prior to trapping and for the year after trapping. Although their judgment may not be entirely accurate, it is likely to be conservative, and their opinion is very important in gauging the public relations value of the program. This information has been collected for each of the past six years. Where numbers of different kinds of livestock and poultry were reported, they were evaluated in terms of dollars based on 1948 figures from the University of Missouri College of Agriculture.

For the six-year period, 816 farmers reported annual losses before trapping totalling $101,679, and for the year after instituting damage control, $19,774. The resulting saving of $81,905 is an over-all damage reduction averaging 81 per cent for the period. Loss reduction

TABLE 4.—REDUCTION IN LIVESTOCK AND POULTRY LOSSES REPORTED

Fiscal Year	No. Farmers Reporting Losses	Annual Losses[2]		Reduction in Annual Losses	Per Cent Reduction in Losses	Avg. Saving in Annual Loss per Farmer
		Before Trapping	After Trapping			
1948	172	$ 29,968	$ 4,619	$ 25,349	85%	$147.38
1949	220	28,008	5,834	22,174	79%	100.79
1950	113	12,766	2,551	10,215	80%	90.40
1951	115	8,654	2,400	6,254	72%	54.38
1952	128	15,322	3,522	11,800	77%	92.19
1953	68	6,961	848	6,113	88%	89.90
Total	816	$101,679	$19,774	$81,905	81%	$100.37

[2] Value of livestock and poultry was computed from 1948 information from the University of Missouri College of Agriculture.

for each of the six years ranged from 72 per cent to 88 per cent. It is interesting to note that the reduction in evaluated losses produced an annual saving averaging $100.37 per farmer (Table 4). Considering that the average farmer trainee puts in 49.7 hours to achieve this saving (Table 3), his trapping effort is worth about $2.00 an hour to him.

SUMMARY

1. Compared to other methods tried, extension predator control is the best system of providing sufficiently prompt and immediately effective service to all requests for assistance in reducing farm predator damage. Also, once farmers are trained, they can supply control measures at any time needed.

2. Simplified trapping techniques designed for busy farmers and demonstrated by able extension trappers have contributed importantly to the effectiveness of the program.

3. During eight years, 635 demonstrational meetings have been requested and conducted throughout the State, arranged usually through county agricultural extension agents. These meetings have been attended by nearly 16,000 interested farm people, and 5,800 of these have participated in field training, with 873 farmers given further individual assistance.

4. From annual mail surveys during the eight-year period, more than 1,100 farmers reported an average of 49.7 hours per year spent in trapping an average of 9.2 predators each. The total reported catch for fiscal years 1946–53 was 10,195 predators (3,099 coyotes, 5,444 red foxes, 1,555 gray foxes, 66 bobcats, and 31 wild dogs).

5. Average annual damage reduction of 81 per cent, amounting to $100.37 per farmer of 816 reporting, has been attained over a six-year period by farmers who applied their training. They indicate that they are well satisfied with this result.

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QUAIL PREFERENCE FOR SEED OF FARM CROPS

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Introduction

Food habits analyses show what wild animals consume, and for that reason have an important place in the field of wildlife research. Such analyses, however, fail to distinguish between the food preferences of the species concerned and the relative availability of desired foods, two factors which determine what is actually found in an animal's crop or stomach. The present investigation was concerned chiefly with food preferences of the bobwhite quail, *Colinus virginianus*. Preferences were determined by observing and analyzing the reactions of penned bobwhite quail to the seed of a wide variety of farm crops and recognized quail foods. Foods selected for experimentation were thought to be primarily adapted for planting in the north-central portion of Florida, but also in the general southeastern region of the United States. Undoubtedly, differences in palatability of the various foods largely explain the ratings of preference that were observed, but the present study also analyzed other factors that had an influence upon preferences. These factors included apparent olfactory perception, effect of seed placement during the various feeding experiments, and habit.

Still another phase of this investigation was concerned with the competition of other kinds of animals for quail foods and the possible effect of such competition on the availability of those foods. One animal to which particular attention was devoted was the harvester ant, *Pogonomyrmex badius* (Latreille). Native rodents, principally the cotton rat, *Sigmodon hispidus hispidus* Say and Ord, were also studied in this respect. A final phase of this investigation was concerned with observing the effects of feeding unlimited amounts of certain seeds to the birds for protracted periods of time.

These studies were carried out by the senior author at the University of Florida Conservation Reserve, Welaka, Putnam County, Florida, from September, 1949 to January, 1951 in partial fulfillment of the requirements for the degree of Master of Science in Agriculture. The junior author served as co-chairman of the supervisory committee with Dr. P. H. Senn, Head, Department of Agronomy, and of which Dr. Clyde Driggers, Poultry Husbandman, Florida Agricultural Experiment Station, was a member. Grateful acknowledgement for invaluable suggestions is given to Dr. O. Earle Frye, Assistant Director, Florida Game and Fresh Water Fish Commission, who was Federal Aid Coordinator at the time.

Source of Birds Used in Experiments

A total of 88 bobwhite quail was used during these feeding experiments. Twenty-nine of these birds were trapped from the Cecil M. Webb Wildlife Management Area in Charlotte County, South Florida, and the remaining 59 birds were trapped on the grounds of the Conservation Reserve at Welaka. The Charlotte County birds were typical Florida bobwhite, *Colinus virginianus floridanus* (Coues), whereas the Welaka birds were intermediate between this

subspecies and the eastern bobwhite, *Colinus virginianus virginianus* (Linnaeus).

PENS AND FEEDING EQUIPMENT

Quail were confined in slightly modified Coleman brooder pens which consisted of two compartments each 21 inches wide. One compartment was screened with quarter-inch mesh hardware cloth and measured 72 inches long by 13 inches high. At one end was attached a completely enclosed compartment 32 inches long by 24 inches high where it joined the screened portion and 13 inches high at the end.

These pens held either one or two pairs of quail. Each pen was furnished with a dusting box and a supply of drinking water. Standard sanitary measures were practiced to safeguard the health of the birds.

Feeding equipment consisted of divided trays measuring approximately 3 inches wide by 18 inches long by one inch deep. Each tray contained six, twelve, or twenty-four compartments so that a number of seed varieties could be offered simultaneously to the birds.

FEEDING PROCEDURES

NUMBER OF FOOD ITEMS USED.—A total of 53 different food items was included in this series of experiments. This number includes different forms of the same foods as separate items. For example, cracked corn and whole corn, as well as cut chufas and whole chufas were each considered as individual foods. The complete list of different food items used is presented in Table 1.

FEEDING TRIALS.—The unit of measurement for the determination of preferences was the feeding trial. As used in this study, a feeding trial was the

TABLE 1.—COMMON AND SCIENTIFIC NAMES OF SEED VARIETIES USED IN FEEDING TRIALS

COMMON NAME	SCIENTIFIC NAME
GRASSES	
1. Pensacola bahia	*Paspalum notatum* var. *saurae* Parodi
2. Common bahia	*Paspalum notatum* Flügge
3. Dallisgrass	*Paspalum dilatatum* Poir.
4. Carpetgrass	*Axonopus affinis* Chase
5. Gopher rice	*Oryza sativa* L.
6. Pearl rice	*Oryza sativa* L.
7. Sudangrass	*Sorghum sudanense* (Piper) Stapf.
8. Hegari	*Sorghum vulgare* var. *drummondii* (Nees) Hack.
9. Sorghum	*Sorghum vulgare* Pers.
10. Shallu	*Sorghum vulgare* var. *roxburghii* (Stapf.) Haines
11. Cattail millet	*Pennisetum glaucum* (L.) R. Br.
12. German millet	*Setaria italica* (L.) Beauv.
13. Cracked corn, yellow	*Zea mays* L.
14. Whole corn, yellow	*Zea mays* L.
15. Oats	*Avena sativa* L.
16. Rescuegrass	*Bromus catharticus* Vahl.
17. Bermudagrass	*Cynodon dactylon* (L.) Pers.
18. Ryegrass	*Lolium multiflorium* Lam.
19. Switchgrass	*Panicum virgatum* L.
20. Wheat	*Triticum aestivum* L.
21. Alta fescue	*Festuca elatior* L.
22. Abruzzi rye	*Secale cereale* L.
23. Florida black rye	*Secale cereale* L.
LEGUMES	
24. Field pea	*Pisum sativum* var. *arvense* Poir.
25. Bur clover	*Medicago arabica* (L.) Huds.
26. Showy crotalaria	*Crotalaria spectabilis* Roth
27. Thunberg lespedeza	*Lespedeza thunbergii* (D. C.) Nakai
28. Common lespedeza	*Lespedeza striata* (Thunb.) H. & A.
29. Kobe lespedeza	*Lespedeza striata* (Thunb.) H. & A.
30. Bicolor lespedeza	*Lespedeza bicolor* Turcz.
31. Partridge pea	*Chamaecrista fasciculata* (Michx.) Greene
32. White seeded German yellow lupine	*Lupinus angustifolius* L.
33. Crescent sweet lupine	*Lupinus angustifolius* L.
34. Buckley sweet lupine	*Lupinus angustifolius* L.
35. Sweet blue lupine	*Lupinus angustifolius* L.
36. Bitter blue lupine	*Lupinus angustifolius* L.
37. Yellow lupine	*Lupinus luteus* L.
38. Hairy vetch	*Vicia villosa* Roth
39. Sesbania	*Sesbania exaltata* (Raf.) Rydb.
40. White sweet clover	*Melilotus alba* Desv.
41. Yellow sweet clover	*Melilotus officinalis* Lam.
42. White Dutch clover	*Trifolium repens* L.
43. Crimson clover	*Trifolium incarnatum* L.
44. Alyce clover	*Alysicarpus vaginalis* DC.
45. Florida beggarweed	*Desmodium tortuosum* DC.
46. Hairy indigo	*Indigofera hirsuta* L.
47. Blackmedic	*Medicago lupulina* L.
48. Birdsfoot trefoil	*Lotus corniculatus* L.
MISCELLANEOUS	
49. Benne	*Sesamum indicum* L.
50. Rape	*Brassica napus* L.
51. Chufa, cut	*Cyperus esculentus* L.
52. Chufa, whole	*Cyperus esculentus* L.
53. Sunflower	*Helianthus annuus* L.

offering of a predetermined amount of food to one pen of birds (containing either one or two pairs) for a 24-hour period beginning at 8:00 A.M. and ending at the same hour on the following day.

During the course of these experiments there were 6,178 feeding trials conducted involving many different combinations of food items. Some of these trials consisted of as few as 4 items offered at one time, whereas others consisted of the entire 53 food items offered simultaneously. Almost without exception the relative preference of the quail for the different foods was the same regardless of the number of food items used. As a result, in order to simplify the presentation of the data, the preferences presented here are based upon a total of 600 feeding trials in which the 53 food items were offered simultaneously to the birds. This number of trials was obtained through the use of 30 pairs of birds confined in separate pens for a period of 20 days during the month of July.

AMOUNT OF FOOD OFFERED.—After considerable experimentation a total of 10 grams was chosen as the amount of food which would sustain a quail over a 24-hour period. This amount was used in determining the weight of each food item offered during each feeding trial. Accordingly, when the entire 53 food items were offered simultaneously, with two birds per pen, $2 \times 10 \div 53$, or 0.38 gram of each food was presented to the birds, and with four birds to a pen, $4 \times 10 \div 53$, or 0.75 gram of each food was used.

MEASURING UTILIZATION OF FOODS.—Utilization of the different food items by the quail was measured by examining the feed trays at specified times and making a notation only when a given seed was completely consumed. Examinations were made at four times, namely at 9:00 A.M., 3:00 P.M., 6:00 P.M., and finally at 8:00 A.M. the following morning, or 1, 7, 10, and 24 hours, respectively, after the foods were offered to the birds.

Choice, or relative preference, displayed by the quail was indicated by the period during which the different foods were consumed. Depending upon whether a food was completely consumed during the first, second, third, or fourth time interval it was rated as being of first, second, third, or fourth choice, respectively. At the conclusion of each feeding trial any food items that were either incompletely utilized or simply untouched during the 24-hour period were considered as being of fifth choice.

PREFERENCE ORDER DETERMINATION.—The five degrees of choice, as determined above, were subsequently used in the final ranking of each food in its order of preference by the quail. This was done by first totaling for each food the number of times it fell into each choice category. These sums were next expressed as percentages of the total 600 feeding trials and thus represented frequencies of occurrence for each degree of choice.

Final preference orders for each food were determined from the frequencies of occurrence for each choice category. Thus, all food items which were rated as first choice in 50 per cent or more of the feeding trials were arbitrarily placed in Preference Order I. Preference Order II included those items for which the total of the first two degrees of choice was 50 per cent or more. If the total of the first three choice categories for a food was 50 per cent or more, it was placed in Preference Order III. In

Preference Order IV were placed all food items for which the first four degrees of choice totaled 50 per cent or more. Preference Order V included all seeds which occurred in the first four choice categories less than 50 per cent of the time.

NUMERICAL RANKING OF EACH FOOD.—In addition to placing each food item in a preference order, the various items were listed according to their numerical ranking. This was accomplished by averaging the frequencies of occurrence for the different degrees of choice included in each preference order. For example, in Preference Order I the foods were simply listed according to the frequency of occurrence for the first degree of choice. Foods in Preference Order II were arranged according to the average of the frequencies of occurrence for the first two degrees of choice. Seeds in Preference Orders III and IV were ranked in a similar manner. Those food items in Preference Order V were arranged according to increasing frequencies of occurrence for the fifth choice category.

EFFECT OF SEED PLACEMENT ON PREFERENCES.—Two separate feeding experiments were conducted to study the effect of the placement of seeds in the feed trays upon the order of food selection by the birds. Two pens with one pair of birds per pen were used, and 480 feeding trials involving 22 food varieties were completed in these experiments. In one experiment the food items were placed in the same compartment in the feed trays during each feeding trial. In the companion experiment the position of the food items was changed randomly for each trial.

OLFACTORY PERCEPTION.—The role of the sense of smell in enabling quail to select palatable foods received incidental attention in this investigation. Only a single experiment designed to test this sense was conducted. This consisted of burying samples of highly palatable seeds beneath a layer of seeds known to be extremely unpalatable and then noting the reaction of the quail to the combination.

STUDIES WITH NATIVE RODENTS

Since rats and mice are frequently plentiful in certain kinds of quail habitats, an experiment was conducted with them to ascertain their food preferences for a selection of 42 seeds used in the quail tests. This was done by exposing 25 grams of each seed in feed trays for a 45-day period where native rodents were known to occur. Periodic observations were then made on the order of seed removal from the trays. Although the principal rodent in the habitat was the cotton rat, there is a possibility that some other rodents were also present and influenced the amount of seed removed.

SELECTION OF SEEDS BY ANTS

Another phase of this investigation concerned the food habits of the harvester ant. For this purpose 30 divided trays covered with one-quarter-inch mesh hardware cloth were set out randomly over the Reserve. The daily ration placed in each supply unit was 150 grams composed of 30 seed varieties. Observations of the food consumed by the ants were made from one to three times each day.

In order to determine the amount of food consumed by harvester ants, three colonies of them were confined separately by driving into the ground around each nest a metal frame 36 inches square and 24 inches deep with a removable cover of ordinary window screen. Each colony was supplied with unlimited

quantities of food consisting of seed varieties previously shown to be of their highest preference. The amount of food consumed each day was recorded and from these data the average amount utilized per colony was calculated.

NUTRITIONAL STUDIES

Twenty-six pens of birds were used in studies concerning the influence of special diets upon quail. In most instances these pens held both a cock and a hen, but in one instance there was only one bird per pen. This experiment consisted of three 20-day periods, making a total of 60 days in all. During each period selected seed varieties were offered to the birds singly or in combinations of two or three varieties at a time, as indicated in Table 7. The birds were weighed at the beginning of the tests and at the end of each 20-day interval. Any weight change was noted as was also any visible change in the condition of the birds.

During this experiment some of the birds were given a fattening ration either as a part of the tests or to revitalize them after undergoing the rigors of the nutritional studies. This ration was a mixture of seeds that had been shown previously to be readily acceptable by quail. It consisted of equal parts by weight of Kobe lespedeza, hegari, Sudan grass, German millet, cattail millet, wheat, yellow corn, and Florida beggarweed.

RESULTS AND DISCUSSION

FOOD PREFERENCES SHOWN BY QUAIL.—Results obtained in these studies indicate that quail are highly selective in their feeding habits when foods of a wide range of palatability are offered to them. Although not all birds consume identical foods, preferences of individual quail are similar enough so that a series of foods can be rated according to the order in which they are taken by the birds. Table 2 presents data concerning the relative use by quail of the series of 53 foods tested in the present investigation. These data are summarized in Table 3 as to the distribution of grasses, legumes, and miscellaneous plants in each preference order.

The summarized data presented in Table 3 indicate that quail generally prefer seeds of grasses to those of legumes. For example, in Preference Order I approximately 73 per cent of the food items are grasses and only 9 per cent are legumes. Conversely, in Preference Order V only 22 per cent of the food items are grasses while over 61 per cent are classed as legumes. These relationships can also be expressed as percentages of the total number of grasses or legumes in each preference order. On this basis 8 (35 per cent) of the 23 grasses occurred in Preference Order I, whereas only 4 (17 per cent) are included in Preference Order V. In regard to the legumes, only one (4 per cent) of the 25 species is listed among the food items in Preference Order I, but 11 (44 per cent) occurred in Preference Order V.

It should be pointed out that the above preferences were based upon experiments conducted during the month of July when grass seeds are usually abundant. Consequently one might expect that quail would normally consume grass seeds at that time, and that the high rating of grasses shown in Tables 2 and 3 is merely a reflection of seasonal food preference. However, the same relative preference for grass seeds over leguminous seeds was shown by other experiments regardless of the time of the year during which they were conducted.

TABLE 2.—RELATIVE PREFERENCES OF PENNED BOBWHITE QUAIL FOR 53 SELECTED FOODS OFFERED SIMULTANEOUSLY IN 600 FEEDING TRIALS BASED UPON FREQUENCIES OF OCCURRENCE FOR EACH DEGREE OF CHOICE EXPRESSED AS PERCENTAGES OF THE TOTAL NUMBER OF TRIALS

Food Item	Preference		Choice Category				
	Order	Numerical	First	Second	Third	Fourth	Fifth
Sorghum	I	1	94.0	6.0	0.0	0.0	0.0
Wheat	I	2	83.3	16.0	0.7	0.0	0.0
Shallu	I	3	83.0	13.0	4.0	0.0	0.0
Cattail millet	I	4	81.5	5.5	13.0	0.0	0.0
German millet	I	5	81.0	2.6	10.3	5.7	0.4
Switchgrass	I	6	80.0	20.0	0.0	0.0	0.0
Hegari	I	7	77.0	19.5	3.5	0.0	0.0
Sudangrass	I	8	72.5	18.0	2.6	5.3	1.6
Benne	I	9	67.0	20.2	7.7	3.3	1.8
Rape	I	10	62.4	26.0	8.4	3.2	0.0
Thunberg lespedeza	I	11	58.0	42.0	0.0	0.0	0.0
Abruzzi rye	II	12	44.0	56.0	0.0	0.0	0.0
Carpetgrass	II	13	46.4	43.5	8.6	1.5	0.0
Bicolor lespedeza	II	14	39.5	38.5	16.2	5.8	0.0
Cracked corn, yellow	II	15	26.9	47.1	12.0	13.0	1.0
Hairy vetch	II	16	20.0	46.0	10.6	19.0	4.4
Florida black rye	II	17	11.8	45.2	32.5	8.6	1.9
White clover, Dutch	II	18	28.0	22.0	26.0	24.0	0.0
Pearl rice	III	19	21.5	12.0	48.5	12.5	5.5
Gopher rice	III	20	13.1	30.6	27.0	26.9	2.4
Alyce clover	III	21	3.2	25.0	36.0	15.8	20.0
Crimson clover	III	22	10.3	25.0	28.7	28.7	7.3
Oats	III	23	5.0	26.5	26.7	15.4	26.4
Partridge pea	IV	24	0.0	16.3	26.3	37.4	20.0
Kobe lespedeza	IV	25	7.3	22.5	11.7	37.5	21.0
Sesbania	IV	26	0.0	6.4	18.2	53.0	22.4
Bitter blue lupine	IV	27	7.6	16.0	10.8	41.0	24.6
Sweet blue lupine	IV	28	0.0	5.0	11.6	58.6	24.8
Rescuegrass	IV	29	2.3	10.0	8.2	46.0	33.5
Birdsfoot trefoil	IV	30	3.0	5.5	7.0	47.5	37.0
Common lespedeza	IV	31	2.0	19.6	16.0	24.4	38.0
Ryegrass	IV	32	0.0	5.7	9.0	45.0	40.3
Whole corn, yellow	IV	33	0.0	0.0	0.0	58.0	42.0
Dallisgrass	IV	34	0.0	0.0	0.0	53.0	47.0
Florida beggarweed	IV	35	0.0	11.0	7.0	32.0	50.0
Yellow lupine	V	36	0.0	9.6	7.8	30.0	52.6
White sweet clover	V	37	0.0	0.0	6.0	36.0	58.0
Pensacola bahia	V	38	0.0	0.0	4.0	32.5	63.5
Sunflower	V	39	3.0	4.0	7.0	19.3	66.7
Common bahia	V	40	0.0	0.0	0.8	32.4	66.8
Field pea (weevily)	V	41	7.0	7.7	10.0	7.3	68.0
Burclover	V	42	0.0	0.0	2.7	20.5	76.8
Blackmedic	V	43	0.0	0.0	0.0	23.0	77.0
Yellow sweet clover	V	44	0.0	1.3	0.0	17.6	81.1
Hairy indigo	V	45	0.0	0.0	0.0	15.8	84.2
German yellow lupine	V	46	0.0	0.0	0.0	1.0	99.0
Alta fescue	V	47	0.0	0.0	0.0	0.0	100.0
Chufa, cut (dried)	V	48	0.0	0.0	0.0	0.0	100.0
Chufa, whole	V	49	0.0	0.0	0.0	0.0	100.0
Crescent sweet lupine	V	50	0.0	0.0	0.0	0.0	100.0
Buckley sweet lupine	V	51	0.0	0.0	0.0	0.0	100.0
Bermudagrass	V	52	0.0	0.0	0.0	0.0	100.0
Showy crotalaria	V	53	0.0	0.0	0.0	0.0	100.0

TABLE 3.—DISTRIBUTION OF GRASSES, LEGUMES, AND MISCELLANEOUS PLANTS IN EACH PREFERENCE ORDER

Preference Order	Total No. of Food Items	Grasses		Legumes		Miscellaneous	
		No.	% Total Items	No.	% Total Items	No.	% Total Items
I	11	8	72.7	1	9.1	2	18.2
II	7	4	57.2	3	42.8	0	0
III	5	3	60.0	2	40.0	0	0
IV	12	4	33.3	8	66.7	0	0
V	18	4	22.2	11	61.1	3	16.7
Totals	53	23	....	25	....	5	....

The preference of quail for grass seeds over leguminous seeds is particularly significant since most investigators of the food habits of wild quail regard legumes as the more highly preferred of these two kinds of foods. Massey (1938) is one notable exception in this respect. This investigator points out that, although leguminous seeds are normally available throughout the fall months, they usually are not consumed in quantity until late winter. Here is definite indication of the preference by quail for grass seeds over leguminous seeds. This fact is also recognized by Frye (1954). The increasing use of legumes as the fall and winter seasons progress is substantiated by the work of Baldwin and Handley (1946), Korschgen (1948), Nestler *et al.* (1945), and Laessle (1945). However, no attempt is made by these workers to distinguish between the selection of foods on the basis of preference and the selection of foods as conditioned by the relative availability of each one.

The delayed but normally high consumption of leguminous seeds by quail can quite logically be correlated with the declining availability of the more readily acceptable grass seeds. As we shall see later, harvester ants and native rodents, and very probably numbers of smaller song birds, have food preferences closely approximating those of bobwhite quail. Consequently the supply of grass seed is fed upon by many different forms of animal life, causing it to become quickly exhausted. With the disappearance of the more highly preferred grass seeds (and possibly other preferred foods) quail and other granivorous forms of wildlife must resort to the harder-coated, less preferred leguminous seeds that remain.

Data in Table 2 indicate that quail generally have a higher preference for seeds of annual grasses than for those of perennial grasses. Such a situation could be anticipated, however, from the extensive use by quail of vegetation types that characterize the earlier stages of succession when seed-bearing annual or biennial plants predominate. Of the perennial grasses tested in the present study, only switchgrass, in Preference Order I, and carpetgrass, in Preference Order II, rated high enough to warrant their use in permanent quail food plantings.

In regard to some better known quail food plants, Table 2 shows some interesting comparisons between them and other foods tested. For example, Thunberg lespedeza, a perennial closely resembling bicolor lespedeza but better

adapted to sandy soils such as occur in Florida, is listed as the last plant in Preference Order I with frequencies of occurrence of 58 per cent and 42 per cent for the first and second choice categories respectively. In contrast to this, bicolor lespedeza is ranked as the third plant in Preference Order II with frequencies of occurrence of 39.5 per cent, 38.5 per cent, 16.2 per cent, and 5.8 per cent for the first four degrees of choice respectively. According to Murray (1951) quail in the wild also showed this same relative preference for thunberg lespedeza over bicolor lespedeza.

Other well known quail foods, particularly in the Southeast, are partridge pea, common lespedeza, Kobe lespedeza, and Florida beggarweed. These foods all occurred in Preference Order IV, which places them relatively low in the list of quail foods. As pointed out previously, the high rating of these seeds by wild quail can be correlated with the exhaustion of the supply of more highly preferred grass seeds.

EFFECT OF SEED PLACEMENT ON PREFERENCES.—Data obtained from the two feeding experiments designed to test the effect of seed placement on preferences indicate that this factor has little, if any, influence upon the order in which foods are taken by bobwhite quail. Twenty-two varieties of food were used in these experiments (Table 4). It will be noted that all of the seeds occurred in the same preference order regardless of whether they were placed randomly or in the same compartment during each feeding trial. However, there are minor differences in the numerical ranking of the seeds in the two experiments. The largest discrepancy in this respect was with common lespedeza, which ranked tenth when placed in the same feed compartment each time and fourteenth when its position was varied during each feeding trial. These data indicate that quail have definite food preferences irrespective of how the foods are offered to them. They do not feed simply by habit but actually search for those foods that are most acceptable.

OLFACTORY PERCEPTION BY QUAIL.—That quail may have an acutely developed sense of smell and that this sense may play an important role in enabling quail to select palatable foods was indicated by the present investigation. This was demonstrated by burying 5 grams of a highly preferred food, such as German millet, under 10 grams of a food such as Alta fescue, which has a low preference rating, in one compartment of a feed tray. Even though none of it was evident, the quail immediately detected the German millet and consumed it completely. This experiment was repeated using either Bermuda grass or showy crotalaria, two other low preference foods, in place of Alta fescue. In both of these instances, also, the quail were able to detect the German millet underneath. The existence of a keen sense of smell in quail is also substantiated by the work of Frings and Boyd (1952). These workers demonstrated that quail acquired a preference for certain feeders which could only be attributed to the ability of the birds to differentiate odors on them.

Additional evidence of the highly developed olfactory organs in quail was observed in the ability of the birds to detect distant woods fires. This ability was manifested by the behavior of the birds to the presence of smoke in the air. Even before the presence of smoke became apparent, the birds would

become nervous, continually on guard, and erect their crests or spread their tails. From one to several hours later the investigator was able to perceive the smoke by its bluish haze and still later by its odor. It is interesting to note that, while disturbed by smoke, food consumption by the quail was reduced to one-half to one-third of the normal amount.

INFLUENCE OF HABIT ON FOOD PREFERENCES.—Habit was demonstrated to be of negligible importance in affecting the food preferences of bobwhite quail. This conclusion is based upon numerous tests in which various seeds were used in different combinations while the birds were being held pending the receipt of as many varieties of seed as possible. For example, seeds of grasses such as cattail millet and German millet, with which it is safe to assume the birds had never come into contact in the wild, were placed in the first preference order the first time they were offered to the birds. In another instance, switchgrass, the forty-eighth seed to be tried on the quail, was rated as being of first choice on its initial feeding trial.

These data suggest that penned bobwhite quail do not require an introductory period in which to become accustomed to acceptable new foods. This is in contrast to the work of C. O. Handley (in Stoddard, 1931: 125) who reports that wild quail require periods

TABLE 4.—EFFECT OF SEED PLACEMENT ON THE RELATIVE PREFERENCES OF TWO DIFFERENT PAIRS OF PENNED BOBWHITE QUAIL FOR 22 FOOD ITEMS IN A TOTAL OF 480 FEEDING TRIALS

Preference		Food Item	
Order	Numerical	Random Placement	Constant Placement
I	1	Sorghum	Sorghum
I	2	Rape	Cracked corn, yellow
I	3	Abruzzi rye	Rape
I	4	Thunberg lespedeza	Abruzzi rye
I	5	Cracked corn, yellow	Thunberg lespedeza
I	6	Field pea	Field pea
II	7	Florida black rye	Florida black rye
II	8	Carpetgrass	Carpetgrass
III	9	Florida beggarweed	Florida beggarweed
III	10	Alyce clover	Common lespedeza
III	11	Gopher rice	Alyce clover
III	12	Pearl rice	Gopher rice
III	13	White clover, Dutch	Pear rice
III	14	Common lespedeza	White clover, Dutch
III	15	Whole corn, yellow	Whole corn, yellow
IV	16	Sweet blue lupine	Sesbania
IV	17	Bitter blue lupine	Bitter blue lupine
IV	18	Sesbania	Sweet blue lupine
IV	19	Chufa, cut (fresh)	Chufa, cut (fresh)
V	20	Common bahia	Common bahia
V	21	Hairy indigo	Hairy indigo
V	22	Bermudagrass	Bermudagrass

up to three years in length to learn to eat certain varieties of newly introduced foods.

MISCELLANEOUS FACTORS AFFECTING PREFERENCES.—One of the most obvious reasons for a seed being rated low in preference is its toxic effect on the birds. This is definitely the case with showy crotalaria, an introduced cover plant. The seeds of this plant have been shown to be poisonous to quail, chickens, and mourning doves (Nestler and Bailey, 1941). During the present study, when this was the only food offered to the quail for periods as long as seven days, they refused to take it. Possibly some of the other seeds that were unacceptable to the quail might also be of a toxic nature.

The fact that taste might be of some importance to quail in their selection of foods is suggested by their reaction to freshly cut fragments of chufas compared to whole, small chufas of the same size. In a summary of all feeding experiments conducted during this investigation freshly cut chufas were placed in the fourth preference order or 34th in the numerical ranking. This places them on a par with Florida beggarweed. Whole chufas and air-dried fragments of cut chufas were completely unacceptable to the birds according to data contained in Table 2.

Admittedly the olfactory sense might be utilized in the preferential selection of freshly cut chufas over whole, small chufas. However, the fact that the birds failed to detect the chufa scent in the whole tubers indicates that the selection may have been made on the basis of taste alone.

FOOD HABITS OF HARVESTER ANTS.—Studies with harvester ants showed them to be important competitors for bobwhite quail food in terms of both the kinds of seeds consumed and the total amount of food utilized. According to data presented in Table 5 there is a striking similarity between the preferences of quail (based upon the previous experiments using 53 seed varieties simultaneously) and those exhibited by the ants. With the exception of both Pensacola bahia and common bahia the first 14 foods were all rated within four positions of the same place by both ants and quail.

In regard to food preferences of harvester ants it is evident that they also have a strong liking for seeds of grasses. Of the first 9 foods most preferred by harvester ants, 8 are grasses. The fact that the seed of benne was regarded highly by both ants and quail (i.e. in fifth place by the ants and in sixth place by quail) may be due to its grass-like appearance and also to the same components which make it suitable for human consumption.

In addition to having food preferences similar to those of bobwhite quail, harvester ants were shown to consume relatively large amounts of food which they obtained from considerable distances. When supplied with highly acceptable seeds, a colony of ants consumed as much as 80 to 125 grams of food in a day's time. The amount is sufficient to feed a covey of from 8 to 10 quail for the same period of time. On numerous occasions ants were trailed from feeding stations to their colonies, the greatest distance observed being 110 feet. This means that a colony of ants is capable of covering as large an area as seven-eights of an acre in search of its food. With a density of only one colony of harvester ants per acre it is easily seen that highly preferred grass seeds could be almost completely removed by the ants, causing them to be unavailable to quail. This in turn would force

quail and other forms of wildlife to resort to harder-coated but less preferred seeds, such as various legumes and other seeds that might remain.

A further indication of the possible importance of harvester ants in the ecology of the bobwhite quail lies in their wide distribution. According to Smith (1947) they occur in the states bordering the Gulf of Mexico and the Atlantic Ocean from Louisiana to New Jersey. This species is cause for concern among nurserymen because of its habit of stealing seeds from planting beds. Perhaps other members of this genus might also compete with quail and similar granivorous forms of wildlife in other sections of the United States. The genus is widespread, most species occurring west of 95° W and becoming most numerous in the southwest.

FOOD HABITS OF NATIVE RODENTS.—Controlled feeding tests with rodents, principally cotton rats, indicate that their most preferred foods differ sharply from those of quail. Accordingly, these animals preferred chufas, sunflower seeds, and whole yellow corn above all other foods (Table 6). These three species were all rated very low in the quail preference studies. The next preferred foods, listed in the order in which they were taken by cotton rats, were: Sorghum, rice, German millet, cattail millet, wheat, oats, and switchgrass. Among this group several were relatively high on the list of quail foods. These data suggest that, although native rodents most prefer foods that are relatively unacceptable to quail, in the absence of these foods they will turn to some of the preferred quail foods. In view of this situation cotton rats must be considered as offering definite competition to quail, a fact which is substantiated by the work of Stoddard (1931).

NUTRITIONAL STUDIES. — Data presented in Table 7 indicate that during the first 20-day period, in all instances

TABLE 5.—RELATIVE FOOD PREFERENCES OF HARVESTER ANTS COMPARED WITH THOSE OF BOBWHITE QUAIL

Numerical Preference		Food Item	Numerical Preference		Food Item
Ant	Quail		Ant	Quail	
1	2*	Cattail millet	16	7	Rape
2	3	German millet	17	12	Hairy vetch
3	4	Hegari	18	16	Crimson clover
4	1	Sorghum	19	9	Abruzzi rye
5	6	Benne	20	29	Bermudagrass
6	5	Sudangrass	21	18	Sesbania
7	10	Carpetgrass	22	11	Bicolor lespedeza
8	24	Pensacola bahia	23	26	Hairy indigo
9	25	Common bahia	24	28	Alta fescue
10	14	Gopher rice	25	19	Bitter blue lupine
11	13	Pearl rice	26	20	Sweet blue lupine
12	8	Thunberg lespedeza	27	23	Yellow lupine
13	15	Alyce clover	28	27	German yellow lupine
14	17	Partridge pea	29	30	Spectabilis crotalaria
15	22	Florida beggarweed	30	21	Whole corn, yellow

* Numerical preferences for bobwhite quail based upon rank of each food in Table 2.

TABLE 6.—RELATIVE FOOD PREFERENCES OF NATIVE RODENTS (PRINCIPALLY COTTON RATS) WHEN OFFERED 25 GRAMS OF EACH FOOD ITEM FOR A 45-DAY PERIOD

Numerical Preference	Food Item	Numerical Preference	Food Item
1	Chufa, whole	12	Common lespedeza
2	Sunflower	13	Yellow lupine
3	Whole corn, yellow	14	Buckley sweet lupine
4	Sorghum	15	Field pea
5	Pearl rice	16	Florida beggarweed
6	German millet	17	Ryegrass
7	Cattail millet	18	Alta fescue
8	Wheat	19	Pensacola bahia
9	Oats	20	Abruzzi rye
10	Switchgrass	21	Carpetgrass
11	Kobe lespedeza	22	Bermudagrass

NOTE: Very little or none of the following were utilized:

Burclover	German yellow lupine	Sesbania	Alyce clover
Spectabilis crotalaria	Crescent sweet lupine	White sweet clover	Hairy indigo
Thunberg lespedeza	Sweet blue lupine	Yellow sweet clover	Blackmedic
Bicolor lespedeza	Bitter blue lupine	White clover, Dutch	Birdsfoot trefoil
Partridge pea	Hairy vetch	Crimson clover	Rape

where an abundance of a single seed variety was offered to the birds, a decrease in weight resulted. This decrease was smallest (1.3 per cent) in the case of carpetgrass and largest (25.1 per cent, based upon only one bird) for Alta fescue. With the exception of Abruzzi rye, Florida beggarweed, carpetgrass, and Dutch white clover, all decreases were in excess of 2.3 per cent. The magnitude of the decrease, however, showed no correlation with the relative preference exhibited by the quail for the different seeds based upon previous studies. For example, cattail millet and German millet, both in the first preference order, caused weight losses of 12.0 per cent and 11.5 per cent, respectively, whereas hairy indigo, in the fifth preference order, produced a weight loss of only 9.6 per cent.

During the second 20-day period symptoms closely resembling those of vitamin A deficiency in poultry began to appear in many of the birds. These findings were verified by Dr. Clyde Driggers, Poultry Husbandman, Florida Agricultural Experiment Station. Initial stages of this deficiency were characterized by the birds being extremely nervous and easily excited. Secondary stages of the condition consisted of the birds being quiet, sullen, sitting around with ruffled feathers, and discharging slightly from the nostrils. During the final stages of this condition the birds appeared very tired, showed some cloudiness in the eyes, and discharged freely from the nostrils.

It will be observed that both Florida beggarweed and carpetgrass were outstanding in their ability to maintain the birds' weights and failed to produce vitamin A deficiency symptoms for a 40-day period. Many of the other seeds, even in combination with another variety, had produced secondary symptoms of the lack of vitamin A by this time. It is also important to note that where the diet was either changed to a

different seed variety or another seed was added to the diet of the birds, in 13 out of a total of 16 instances an increase in weight resulted. However, regardless of the tendency for the birds to gain weight when the diet was changed, in 8 out of the 13 pens which showed weight increases, either initial or secondary stages of vitamin A deficiency developed.

During the third 20-day period of this experiment the birds in Pens 2 through 10, inclusive, were utilized for further preference studies and were therefore excluded from these tests. All of the remaining birds on the specialized diets developed either second or third degree symptoms characteristic of vitamin A deficient conditions. This was true in spite of the fact that some birds showed weight increases as their diet was changed.

These data indicate that continuously restricted diets consisting of from one to three seed varieties almost invariably cause symptoms that are characteristic of a shortage of vitamin A. Quail generally maintained their body weight for only 7 to 15 days on a diet consisting solely of one seed variety even though it was highly preferred seed as determined by the preference experiments. Carpetgrass and Florida beggarweed are notable exceptions in these respects, since they were acceptable to the birds for as long as 40 days, in addition to maintaining body weight and not causing vitamin A deficiency conditions. One important conclusion from these studies is that, in order to maintain a healthful physical condition, quail require a diet composed of a number of different kinds of food items.

Another important point brought out by these nutritional studies is that hen quail are much more susceptible to mortality from inadequate diets than are cock quail. Accordingly, Table 7 lists 12 hen birds as dying during or after the tests as compared to only 5 cock birds. In other words, these data indicate that female bobwhite quail are over twice as likely to die from improper diets as are male quail. This one instance of differential mortality between the sexes in bobwhite quail may partially explain the well known fact that there is usually a preponderance of males in wild populations of these birds.

SUMMARY AND CONCLUSIONS

1. A study of the relative preferences of penned bobwhite quail for a wide variety of seeds was conducted on the grounds of the University of Florida Conservation Reserve, Welaka, Florida from September 1949 to January 1951.

2. Additional studies were made on such subjects as the effect of seed placement on preferences; olfactory perception; food preferences of harvester ants and native rodents, principally the cotton rat; and the effect of diets consisting of a restricted number of seeds on quail.

3. Although there were 6,178 feeding trials conducted during this investigation, preferences presented here are based upon a series of 600 feeding trials in which the 53 different food items were offered simultaneously to the birds.

4. Quail generally prefer grass seeds over those of legumes, and, among the grasses, seeds of annual grasses over those of perennial grasses.

5. Recognized quail foods such as partridge pea, common lespedeza, and Florida beggarweed were all placed relatively low in the list of quail foods.

6. When offered a variety of foods having a wide range of palatability quail search out the most preferred foods regardless of whether the place-

TABLE 7.—EFFECTS OF OFFERING SPECIALIZED DIETS TO PENNED BOBWHITE QUAIL FOR THREE CONSECUTIVE TWENTY-DAY PERIODS

Pen No.	FIRST TWENTY-DAY PERIOD					SECOND TWENTY-DAY PERIOD			
	Food Item	Initial Weight	20-day Weight	Weight Change	% Change	Food Item(s)	40-day Weight	Weight Change	% Change
1	Alta fescue (cock only)	135.4*	101.4	−34.0	−25.1	Fattening mix	.....	.....	.....
2	Abruzzi rye	291.5	285.7	−5.8	−1.9	Abruzzi rye & (added) Florida beggarweed	291.4	+5.7	+2.0[x]
3	Fattening mix	243.7	254.6	+10.9	+4.5	Fattening mix	289.5	+34.9	+13.7
4	Chufa, cut (fresh)	261.4	228.4	−33.0	−12.6	Fattening mix	277.5	+49.1	+21.5[x]
5	Florida beggarweed	302.5	295.5	−7.0	−2.3	Florida beggarweed	302.1	+6.6	+2.2
6	Yellow corn, whole	289.5	227.6	−61.9	−21.3	Yellow corn & (added) Florida beggarweed	276.5	+48.9	+21.5
7	Rape	280.0	251.7	−28.3	−10.1	Fattening mix	266.4	+14.7	+5.8
8	Wheat	299.2	266.7	−22.5	−7.5	Wheat & (added) yellow corn	288.0	+21.3	+8.0
9	Common bahia	264.5	228.4	−36.1	−13.6	Fattening mix	273.4	+45.0	+19.8
10	Carpetgrass	301.2	297.2	−4.0	−1.3	Carpetgrass	301.0	+3.8	+1.2
11	Hegari	312.8	295.7	−17.1	−5.4	Hegari	280.0	−15.7	−5.3[y]
12	Sorghum	327.1	308.6	−18.5	−5.6	Florida beggarweed	285.4	−23.2	−7.3
13	Pearl rice	280.0	258.3	−21.7	−7.7	Pearl rice	249.4	−8.9	−3.4[y]
14	Gopher rice	258.3	237.3	−21.0	−8.1	Gopher rice	231.0	−6.3	−2.6[y]
15	Alyce clover	254.5	242.8	−11.7	−4.3	Abruzzi rye	252.1	+9.3	+3.8[x]
16	Bitter blue lupine	300.4	278.6	−21.8	−7.2	Bitter blue lupine & (added) rape	311.5	+32.9	+11.9[y]
17	Fattening mix	207.3	225.3	+18.0	+8.6	Fattening mix	268.1	+42.8	+19.0
18	Hairy indigo	259.3	230.1	−29.2	−9.6	Hairy indigo & (added) carpetgrass	285.0	+54.9	+23.8[x]
19	Field pea	304.5	272.4	−32.1	−10.5	Field pea & (added) carpetgrass	298.1	+25.7	+9.8[x]
20	Common bahia	291.6	250.0	−41.6	−14.2	Common bahia & (added) sesbania	239.5	−10.5	−4.2[y]
21	White clover, Dutch	292.6	287.6	−5.0	−1.7	Cattail millet	288.7	+1.1	+0.4[y]
22	Cattail millet	267.3	235.2	−32.1	−12.0	German millet & hegari	241.4	+6.2	+2.2[y]
23	German millet	295.3	261.2	−34.1	−11.5	German millet & (added) Florida beggarweed	279.3	+18.1	+6.8
24**	Birdsfoot trefoil	237.4	248.0	+10.6	+4.4[x]	.....	.....	.....	.....
25**	Oats	316.0	292.9	−23.1	−7.4[x]	.....	.....	.....	.....
26**	Alyceclover & hegari	229.0	260.0	+31.0	+13.5[x]	.....	.....	.....	.....

TABLE 7—(Continued)

Pen No.	THIRD TWENTY-DAY PERIOD				Remarks
	Food Item(s)	60-day Weight	Weight Change	% Change	
1	.....	.....	.....	.....	Bird died on 34th day of tests, weight 67.4 gms; death probably partly due to fibrous matter in Alta fescue.
2	.....	.....	.....	.....	Birds used for preference tests after 40 days.
3	.....	.....	.....	.....	..... Ditto .....
4	.....	.....	.....	.....	..... Ditto .....
5	.....	.....	.....	.....	..... Ditto .....
6	.....	.....	.....	.....	..... Ditto .....
7	.....	.....	.....	.....	..... Ditto .....
8	.....	.....	.....	.....	..... Ditto .....
9	.....	.....	.....	.....	..... Ditto .....
10	.....	.....	.....	.....	..... Ditto .....
11	Hegari.....	268.5	−21.5	−7.7[z]	Hen died at 124.4 gms 3 days after close of tests.***
12	Yellow sweet clover.....	280.0	−5.4	−1.6[z]	Hen died at 147.0 gms 25 days after close of tests.
13	Pensacola bahia.....	245.4	−4.0	−1.6[z]	Hen died at 79.5 gms 22 days after close of tests; cock died at 137.0 gms 29 days later.
14	Cattail millet.....	276.2	+45.2	+19.6[z]	Hen died at 138.4 gms 4 days after close of tests.
15	Hairy vetch & carpetgrass.....	280.0	+27.9	+11.0[y]	Hen died at 121.4 gms 3 days after close of tests.
16	Bitter blue lupine, rape, & (added) bicolor lespedeza.....	301.0	−10.5	−3.3[z]	Hen died at 146.7 gms 7 days after close of tests.
17	Fattening mix.....	299.6	+31.5	+11.7	.....
18	Alyce clover.....	277.5	−7.5	−2.6[y]	Cock died at 143.2 gms 9 days after close of tests.
19	*Scleria* sp.****.....	286.7	−11.4	−3.9[z]	Cock died at 147.2 gms 29 days after close of tests.
20	Common bahia & sesbania.....	.....	.....	.....	Discontinued due to nutritional condition; hen died at 142.6 gms 31 days after close of tests.
21	Cattail millet.....	265.3	−23.4	−8.1[y]	Hen died at 131.3 gms 5 days after close of tests.
22	German millet, hegari, & (added) carpetgrass & bicolor lespedeza	276.4	+35.0	+14.5[y]	.....
23	German millet & Florida beggarweed.....	.....	.....	.....	Discontinued due to nutritional condition; hen died at 151.3 gms 2 days after close of tests.
24	.....	.....	.....	.....	Hen died at 127.4 gms 6 days after close of tests.
25	.....	.....	.....	.....	Hen died at 119.4 gms 1 day after close of tests.
26	.....	.....	.....	.....	Hen died at 138.3 gms 4 days after close of tests; cock died at 124.9 gms 3 days later.

* All weights in grams and for one *pair* of birds unless otherwise noted.

** Birds in pens 24, 25, and 26 captured on 37th day of the experiment; placed on a specialized diet only during the third twenty-day period.

*** Unless otherwise noted all birds that died had symptoms characteristic of vitamin A deficiency.

**** This is a wild plant which is an important source of quail food in South Florida (Frye, 1954).

[x] Early stages of vitamin A deficiency.

[y] Secondary stages of vitamin A deficiency.

[z] Final stages of vitamin A deficiency.

ment of the foods is varied or kept constant over a period of time.

7. Indications are that quail have a well developed sense of smell which is useful for detecting palatable foods and warning of possible danger in the form of fire.

8. Penned bobwhite quail need no introductory period in which to become accustomed to new foods.

9. Some foods are unacceptable to quail because of their toxic effects.

10. Taste may be of some value to quail in enabling them to select palatable foods.

11. Harvester ants have food preferences that closely parallel those of bobwhite quail. As few as one colony of these ants per acre can consume as much food as a covey of 8 to 10 quail and could account for a shortage of preferred quail foods.

12. The most preferred foods of cotton rats and other native rodents were among those of low preference to quail, but, since native rodents also readily accept some of the better quail foods, they must be considered as competing directly with quail.

13. When quail were fed diets consisting of one kind of seed for a protracted period of time, symptoms characteristic of vitamin A deficiency developed after 20 days, and changing the diet to another kind of seed or adding another one or two kinds of seed to the diet failed to alleviate these conditions.

14. Hen quail are over twice as susceptible as cock quail to mortality from inadequate diets.

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SEASONAL AVAILABILITY OF CERTAIN BUSH LESPEDEZA AND PARTRIDGE PEA SEED AS DETERMINED FROM GROUND SAMPLES

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Marco Polo, in his travels in the Far East, found Kublai Khan using food patches for game in the year 1270. This is the earliest recorded use of food plots for wildlife. In America, Pennsylvania is credited with being first to utilize such food patches (1917). Since that time, the use of food plantings has become a general practice for many species. In the earlier years of experimental use of game food patches in the United States, mostly annual grains were planted.

Many of the grains tried in earlier years were found to be readily accepted by quail. The difficulties with such grains, however, were that they required annual replanting and were taken by a host of other species, which depleted the supply of food before the season of food shortage arrived.

In about 1940, game authorities in the southeast became interested in *Lespedeza bicolor* as a quail food plant. This shrubby lespedeza had first been introduced from Asia as an ornamental. Later it was used some as an erosion control plant for gullies. The first records of bicolor serving as an important source of food for quail were obtained at Rock Hill, South Carolina in the winter of 1938–39 (Davison, 1943). Experimental work with bicolor at the Alabama Cooperative Wildlife Research Unit began in the spring of 1941, when transplants were received from the Soil Conservation Service Nursery at Thorsby, Alabama. The second fall thereafter, quail were found making extensive use of this new food supply (Pearson, 1943). In the past 10 years, the use of bicolor for quail habitat development has become widely accepted. Authorities in the southeastern states in the year 1950–51 distributed roughly 39 million bicolor seedlings and 19 thousand pounds of seed (Warvel, 1951).

The State of Florida currently is using *Lespedeza thunbergii* for quail food patches. Virginia and Kentucky are experimenting with *Lespedeza japonica.* Some of the more northern states are working with a strain of *Lespedeza bicolor.*

Alabama and a few other states have recommended large partridge peas, *Chaemaecrista fasciculata* (*Cassia fasciculata*), for quail management. It was found that the partridge pea, while only an annual, gave quick results and reseeded fairly well. It maintained a satisfactory stand for 3 or 4 years without management practices.

Until the present time, the yield of these various quail food plants has been compared only on the basis of annual production of seed that could be harvested either by hand or by combine.

Reported in this study is a new technique that has made it possible to measure and compare relative availability of seed to quail throughout the year. Availability is based on the volume of

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seed recovered from square-foot samples of ground surface in the patches. Comparisons have been made on a seasonal basis.

METHODS

FIELD COLLECTION. Equipment for collecting ground samples for the quail food availability studies consisted of a wooden frame with an opening exactly one foot square, a knife with a 7-inch long blade, and a small scoop made from a piece of sheet iron.

The ground samples were collected on a systematic basis. Once inside the boundary of the study plot, the collector paced off five steps. At this point he placed the square collecting frame at the toe of his right foot. The knife was then used to cut all the vegetation along the inside edge of the frame. The vegetative matter, including leaves, grass, and other litter, was next scraped from the inside of the frame and put into a #16 paper bag. All loose material was scraped clean to solid earth so that no seeds were left in the one square-foot sample. Information recorded on the bag consisted of patch number, date, species, and sample number. The operator then stepped off an additional five paces, placed the frame as before and collected the second sample. This process was repeated until the total number of samples for that period had been collected. The direction of the pacing for locating the ground samples in strip patches was governed by the shape of the patch. In large block patches the pacing was at right angles to the edge. The number of samples per patch per collection varied from 12 to 20, with 15 being eventually selected as adequate for the purpose (Haugen and Fitch, 1953). Collections made within a given season were combined in computing average availability. Samples collected were temporarily stored in the laboratory until thoroughly dry.

SEPARATING SEED. The actual process of separating the seed from the debris consisted of two principal steps.

1. The dried material was crushed between the hands and was then put into the hopper of a small "Grain, Seed and Bean Cleaner" called "The Clipper," manufactured by the A. T. Ferrell and Company, Saginaw, Michigan. For partridge peas, a bottom screen with round 1/12-inch holes and a top screen with slits 6/64″ wide by 3/4″ long were used in the seed cleaner. For bicolor, a bottom screen with round holes 7/64″ in diameter and a top screen with oblong slits 6/64″ by 3/4″ were utilized. The material was re-run through this cleaner as many as four to five times in order to remove as much of the debris as possible from the seed. A few very small bicolor seed may have been lost in the cleaning process. However, repeated checks on technique indicated that such loss was negligible. Material in the seed tray at the end of this cleaning process included seed and particles of gravel and soil of approximately the same size as that of the bicolor seed.
2. The second step of the seed separation process consisted of putting the sample into a beaker of alcohol and stirring the contents. The particles of gravel and seed sank, while the light debris floated on the surface of the alcohol from which it was skimmed and discarded. The heavy material consisting of seed, rock, and some soil particles was then strained from the alcohol and permitted to dry for a few minutes. This material was next placed in a solution of carbon tetrachloride, the specific gravity of

which caused the seed and a few porous soil particles to float while gravel particles sank to the bottom. The floating material, consisting primarily of clean seed with some soil particles of similar size and specific gravity, was then skimmed from the surface and put on a paper towel to dry. A pair of tweezers was next used to separate the seed from the soil particles. The seed were next measured by volume in a 10cc. graduate.

Seed availability data for various months have been combined and presented as samples of three seasons during each year; winter (January-April), summer (May-September), and fall (October-December).

RESULTS

On the basis of square-foot ground samples, established patches of bicolor (unimproved strain) are dependable sources of food in all seasons and from year to year. Series A and E in Table 1 were both developed productive patches. Series A, which was planted in 1945, had not been harvested in the preceding 4 years. Whether or not the site sampled had been harvested previously to that is not known. On the basis of 287 samples, the seed available on the ground in this patch were found to range from 4.7 cc./sq. foot in the fall of 1950, to 15.8 cc./sq. foot in the winter of 1951 (Table 1). In the winter of 1950, 10.4 cc. of seed per square foot were found. Since a full quail crop is about equal to 10 cc., this means that there was available approximately one crop full per square foot. The trend in availability during the winter season in 1950, 1951,

TABLE 1.—SEASONAL AVAILABILITY OF VARIOUS QUAIL FOODS IN CUBIC CENTIMETERS PER SQUARE FOOT

Species	Date planted	Units	Available volume of seed								
			1949	1950			1951			1952	
			Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter	Summer
Lespedeza bicolor Series A	1945	cc.	6.2	5.8	6.2	4.7	10.4	8.4	5.6	15.8	8.4
		Lb./A	462	432	462	350	774	626	417	1,177	626
		No. samples	(12)	(35)	(24)	(40)	(61)	(40)	(30)	(30)	(15)
E	1945	cc.					9.7			7.8	
		Lb./A					722			581	
		No. samples					(20)			(15)	
F	1950	cc.				0.1	0.1			0.9	0.2
		Lb./A				7	7			67	15
		No. samples				(12)	(40)			(15)	(15)
Lespedeza thunbergii	1945	cc.					2.8		6.2	2.7	0.9
		Lb./A					204		452	197	66
		No. samples					(20)		(15)	(30)	(15)
Lespedeza cyrtobotrya	1945	cc.							5.6	2.6	
		Lb./A							407	189	
		No. samples							(15)	(30)	
Chaemaecrista fasciculata Series B	1945	cc.	2.6	1.7	1.2	2.1	1.2	0.7		0.5	
		Lb./A	202	132	93	163	93	54		39	
		No. samples	(13)	(24)	(35)	(20)	(60)	(40)		(15)	
Series G	1950	cc.				6.6	3.9				
		Lb./A				512	302				
		No. samples				(12)	(40)				

and 1952, shows that the patch had an increasing surplus of seed that accumulated each year.

Patch E, which had been harvested for seed each fall, had a supply of 9.7 cc./sq. ft. in winter, 1951, and 7.8 cc./sq. ft. in the winter of 1952. A harvest of 125 lbs. clean seed per acre was taken from this patch in November of 1952. At this rate, roughly 1.7 cc. per square foot were removed by harvesting with a combine. The efficiency of the harvesting operations, as influenced by a hard rain or wind when the seeds are ripe, could easily have caused the variation in seed availability shown in Patch E. In any event, both quantities shown were more than adequate as a source of food for local quail populations.

Patch F, in the winter following its second season of growth had only 0.9 cc./sq. ft. Even though the individual plants were fully grown in height, the tops were not yet dense enough to produce a good seed crop.

Lespedeza thunbergii and *Lespedeza cyrtobotrya*, which occupied ground more fertile and moist than that on which the bicolor stands were located, were found low in food availability during winter in comparison to the equally old stand of bicolor (Table 1). The availability of seed of these two species during the fall of 1950, however, was approximately equal to that for bicolor.

The figures for *thunbergii* and *cyrtobotrya* indicate that much of their seed may be depleted rather quickly during fall and winter. Since the seed of these species is about twice as large in size as that of bicolor, it is conceivable that competing species as well as quail might deplete the supply more quickly. Information on utilization of these two species of plants by rodents and nongame birds is not available at this time.

Studies on partridge pea availability were made on two patches, a new good first year stand (Series G) and an old stand (Series B) that was in its fourth year when the study started. The availability of partridge pea seed during the first fall, as shown by patch G (6.6 cc./sq. ft.), was approximately equal to the food supply available in well-established *bicolor*, *thunbergii*, or *cyrtobotrya* patches, but the winter availability was below that for bicolor. Data on Series B show that by the time a partridge pea patch is 4 to 7 years old without benefit of maintenance (disking or fire), it is very low in production of seed.

Information on relative size, volume, and numbers of seed per pound is given in Table 2. The computations on numbers of seed per cubic centimeter and pound are based on the samples involved in Table 1.

TABLE 2.—COMPARATIVE DATA ON VOLUME AND NUMBER OF SEED PER POUND OF CERTAIN QUAIL FOODS

Species	Vol. in cc./lb.	No. seed/cc.	No. seed/lb.
Lespedeza bicolor	585	135	78,975
Lespedeza thunbergii	598	76	45,448
Lespedeza cyrtobotrya	600	73	43,800
Chaemaecrista fasciculata	562	64	35,968

Bicolor plants in the patches observed dropped their seed from early October through early February. Most of the seed fell in November and early December. On February 1, 1952, only about 5 to 10 per cent of the seed was still on the stalks. From one to 2 per cent remained on the stalks on February 19. Bicolor seed is usually ready for harvesting by combine at Auburn between November 1 and November 10, depending upon frosts. Frosts on October 29 and 30 in 1952, a year with severe summer

drouth, resulted in a yield of "light" seed with poor germination.

Partridge peas shattered seed from late in September through most of October. Series E was ready for combining on October 5, 1950.

DISCUSSION

Information indicates that in the patches studied, bicolor is superior to *thunbergii* and *cyrtobotrya* lespedeza and partridge peas as a year-round dependable food supply. It is also apparent that the lespedezas are slow in getting into production. In fact, the production of partridge peas in their first year is about as good as that of bicolor in its fourth year. After that age, however, bicolor takes the lead and accumulates a surplus which increases each year. Bicolor accordingly provides a sort of "ever normal granary" for the birds, guaranteeing a food supply even if there should be a complete seed crop failure in some years. Mature bicolor stands in the Auburn area have not had a serious seed crop failure in the past 10 years, even in years of severe drouth.

Partridge pea has the advantage of quick production and successful growth on poor soils. There have been fewer failures with partridge peas than any quail food planted in Alabama. It should be disked or burned at least once every 2 years as a maintenance practice. The durability of seed on the ground is not as great as for bicolor as the seeds are more apt to sprout or otherwise be lost. They lack some of the dependability shown by bicolor.

Information suggests the possibility of using both bicolor and partridge peas in development programs which required quick results. In such a case, patches of peas could be used to establish a quick food supply which would last just about long enough to attract the birds until the bicolor comes into significant production, approximately in its third season, depending on weather conditions and soil fertility.

The method described makes it possible to make a better determination of relative availability of quail foods at all seasons of the year. Where the ground is free of snow samples for winter availability should be collected in February.

The determination of the fact that bicolor patches have a large carry-over and an increasing annual surplus of seed is important to management. In order to conserve that carry-over it is important that cultural practices such as annual disking be avoided in order not to destroy that "bank account" of seed. Burning may destroy some of the seed by causing scarification and subsequent germination. On one area, burning during winter increased the number of stems from each root crown.

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MEASURING THE YIELD AND AVAILABILITY OF GAME BIRD FOODS

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Recent developments in the field of wildlife conservation now demand full measurement of the relative values of various wildlife foods. Almost every state has "farm-game development projects" under Pittman-Robertson Federal aid. Many technicians and administrators question the success of these projects, the soundness of techniques, and particularly the suitability of the plants recommended for habitat improvement.

In an effort to answer some of these questions, state conservation agencies have established projects for "Evaluation of Wildlife Management Practices," "Farm-game Research," and "Wildlife Investigations" (Ala., Ark., La., Ky., Mich., N. C., N. Y., Pa., Va.). The objective is to determine the relative success of planting materials and planting designs. Unfortunately, many recent studies provide insufficient data for analysis of a project's worth. Neither do these data permit comparison of results in one soil province or climatic range with those in another on the basis of the most important element—pounds of food produced per acre.

Yields and availability of seed of the plants commonly suggested for game species have not been measured because of a lack of satisfactory methods of study and measurement. Thus, recommendations of food plants for game birds such as quail, doves and ducks are not entirely dependable. Practical needs cannot be satisfied by "estimates" and "logical conclusions." The quantity, quality, and availability of these foods must be known. This is particularly important as wildlife management moves from its traditional dependence on natural environment toward purposeful culture of soil and use of water for greater support and production of wildlife.

Most difficult have been the measurement of (1) seed yields of game bird foods, (2) the rate at which seeds deteriorate when on the ground, and (3) the period of real availability in the field. New methods and new machinery have been developed to measure these important elements in game habitat. Further improvement will be needed, but enough experience is available to provide a guide to wildlife technicians in both research and operations.

Five widely used methods of food evaluation have been employed in studies of wildlife foods:

1. Analysis of the contents of crops, gullets and gizzards. This gives an indication of availability and preference, but sheds little light on seed yields of specific plants. Such information is a weak foundation for land use recommendations.

2. Hand picking or machine harvesting of seeds when part or all of the crop is ripe. This is an unsatisfactory measurement for many of our common wildlife foods such as partridge peas (*Chamaecrista*), ragweed (*Ambrosia*), smartweed (*Polygonum*), *Croton*, vetches (*Vicia*), pine mast, sweet gum (*Liquidambar*), milk peas (*Galactia*), wild beans (*Strophostyles*), jewel weed (*Impatiens*), dayflowers (*Commelina*), foxtail (*Setaria*), *Paspalum*, *Panicum*, pigweeds (*Amaranthus*), etc. Seed of most of these plants ripens unevenly. Some of the ripe seed shatters to the ground while immature seed and flowers remain on the plants. Seed harvest from the plants gives unreliable data regarding yields and little information about the periods when seed are available.

3. Recording of dates when seed first ripened, and closing the period at some "logical" later date. Such observations have proven to be inadequate as a guide to the period of dependable availability.

4. Nutritional studies. These analyze the suitability of plants as food but not their qualities to remain available without deterioration, or to resist loss through competition by unwanted wildlife.

5. Field observations. These have included: (a) recording survival and growth of plant species, (b) estimates of seed yields as "Good" or "Poor", and (c) reports of wildlife using the plantings. These observations rarely answer the questions: How good? Which is dependable? Which is best?

These methods provide useful information but they also leave much to be desired by the scientist who must study wildlife food plants, the agriculturist who must compare cultural methods and results, and the educators and field technicians who bear the responsibilities of their recommendations. Two new methods can now be added:

6. Seed traps to measure seed yields.

7. Ground samples to measure the amount of seed and the period of time it is available to wildlife.

With these added, wildlife-management technicians can have for the first time a dependable analysis of the essential characteristics of a food plant. They can evaluate each plant and compare its usefulness in different climates, on various soils and under different cultural methods.

SEED TRAPS

A seed trap (Fig. 1) is a device which catches seeds that fall upon a measured area of ground surface. It must protect the seed from rodents, birds and any unusual weathering. Its essentials are (1) a size by which its catch is easily converted to pounds per acre, (2) a coarse screen over the top, (3) a fine screen at the bottom, and (4) a device to keep

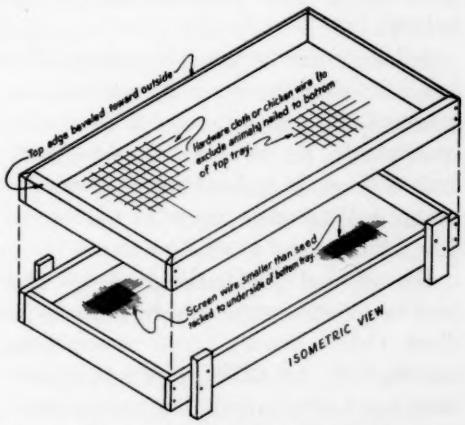

Top edge beveled toward outside
Hardware cloth or chicken wire to exclude animals nailed to bottom of top tray
Screen wire smaller than seed nailed to underside of bottom tray
ISOMETRIC VIEW

FIG. 1. A trap for catching seeds.

the trap bottom off the ground to permit good air drainage. When the box is set tightly on the ground, its sides reduce wind currents and thereby maintain a condition favorable to molds and rot.

The size of the seed trap can be designed to fit beneath the plant to be studied. Various sizes have been used successfully for the bush lespedezas: 12″ x 24″, 6″ x 6″, 12″ x 12″, 6″ x 36″, and as large as one square meter. Measurements are inside dimension.

A depth between screens of 2 or 3 inches is sufficient. The frame (sides) of the trap may be made either of wood or sheet metal. If wood is used, the top of the boards must be beveled to a sharp inner edge so that seeds will not bounce into the trap. Hardware screen of 1/4- or 3/8-inch mesh is satisfactory for most plant seeds. A larger mesh makes reliable results impossible because mice can get through a square as small as 1/2 inch. Window screen is used on the bottom.

A long, narrow trap is required for low and close growing plants such as smartweeds, ragweeds and grasses. For such plants, we use traps 6 inches wide and 12, 24 or 36 inches long. Still smaller plants may require traps as narrow as 3 or 4 inches and as shallow as one inch.

Downs and McQuilkin (1944) used seed traps one meter square to measure acorn yields. Moody (1953) made similar traps 36″ by 43.56″ (1568.16 square inches or 1/4 milacre). The frames were 1″ x 6″ boards, tops were 2-inch mesh poultry wire, and bottoms were 1/4-inch hardware mesh. Moody's traps were supported approximately 30 inches above the ground.

The amount of seed which falls into a small trap can be measured by weighing it in tenths of grams. Table 1 (condensed from one developed by L. M. Dickerson) converts metric measurements to pounds per acre—the practical goal of such studies.

TABLE 1.—CONVERSION OF GRAMS PER SAMPLE TO POUNDS PER ACRE

Weight of Sample in Grams	Pounds Per Acre for Various Size Seed Traps				
	6″ x 6″	6″ x 12″	1′ x 1′	1′ x 2′	2′ x 2′
0.1	38	19	10	5	2.5
0.2	76	38	19	10	5
0.3	115	57	29	14	7
0.4	154	77	38	19	10
0.5	192	96	48	24	12
0.6	230	115	58	29	14
0.7	269	134	67	34	17
0.8	307	154	77	38	19
0.9	346	173	86	43	22
1	384	192	96	48	24
2	768	384	192	96	48
3	1152	576	288	144	72
4	1536	768	384	192	96
5	1920	960	480	240	120
6	2304	1152	576	288	144
7	2688	1344	672	336	168
8	3072	1536	768	384	192
9	3456	1728	864	432	216
10	3840	1920	960	480	240
20	....	3840	1920	960	480
30	....	....	2880	1440	720
40	....	....	3840	1920	960
80	....	....	....	3840	1920

To use the seed-trap method to obtain *average* yields requires random sampling. Dickerson used 3 to 5 boxes (2 sq. ft. each) in 1/8-acre plantings of bush lespedeza for tentative measurement of average yields. Haugen (1955) took 10 to 20 samples, for dependable averages, regardless of the size of patches which ranged from 1/8 acre to more than 3 acres.

In 1953, Graetz placed twelve 2-square-foot seed traps under *Persicaria orientalis* growing on .337 acres. He also collected all the seed from the total acreage by spreading burlap between the rows. The twelve samples indicated a yield of 2022 pounds per acre. The actual harvested yield was 1853 pounds per acre. The latter figure makes no allowance for loss to rodents and birds, but observations indicated that such losses were small. Mice had been poi-

soned soon after their depredations became evident and no noticeable use was made of these seeds by birds.

Seed traps may be used to measure the rate of seed shattering as well as total seed yield. For example, Mr. Eugene Shuffet, a farmer-cooperator, measured the fall of Strain 101 bicolor lespedeza seed in a planting in Green County, Kentucky, in the winter of 1951–52. The rates of 17 per cent in November, 30 per cent in December, 34 per cent in January, 13 per cent in February, and 6 per cent in March are equivalent to pounds per acre as follows: November, 136; December, 240; January, 272; February, 104; March, 48—a total of 800 pounds per acre. In another plot in Barren County, 96 per cent of the seed had shattered by January 12.

We also use the seed traps to compare natural yields with those from cultured plots of the same species, and measure the effects on seed production of fertilization, cultivation, spacing, etc. It is a good means of harvesting small samples of seeds from promising individual plants or several plants of one species. Such studies give us basic information about new plants.

SEED CLEANERS

Between the collection of seed from the traps and weighing of the sample, comes the task of hulling the seed and separating it from leaves, other seed and debris. The hulls of bush lespedeza seeds, for example, must be removed before weighing since quail remove the hulls as they eat these seeds. Hand cleaning is laborious and slow.

For the seed-cleaning task, Graetz (1953) developed a mechanical cleaner which combines an ordinary "clipper mill" seed cleaner with parts of an old vacuum cleaner (Fig. 2). The combination requires a vacuum cleaner motor and suction device, a rheostat for regulating the motor speed, and the seed cleaner with standard sets of screens. With this device, a sample of seed can be run and rerun through the cleaning system until it is thoroughly hulled and separated from trash. Usually from one to five minutes actual running time is required per sample.

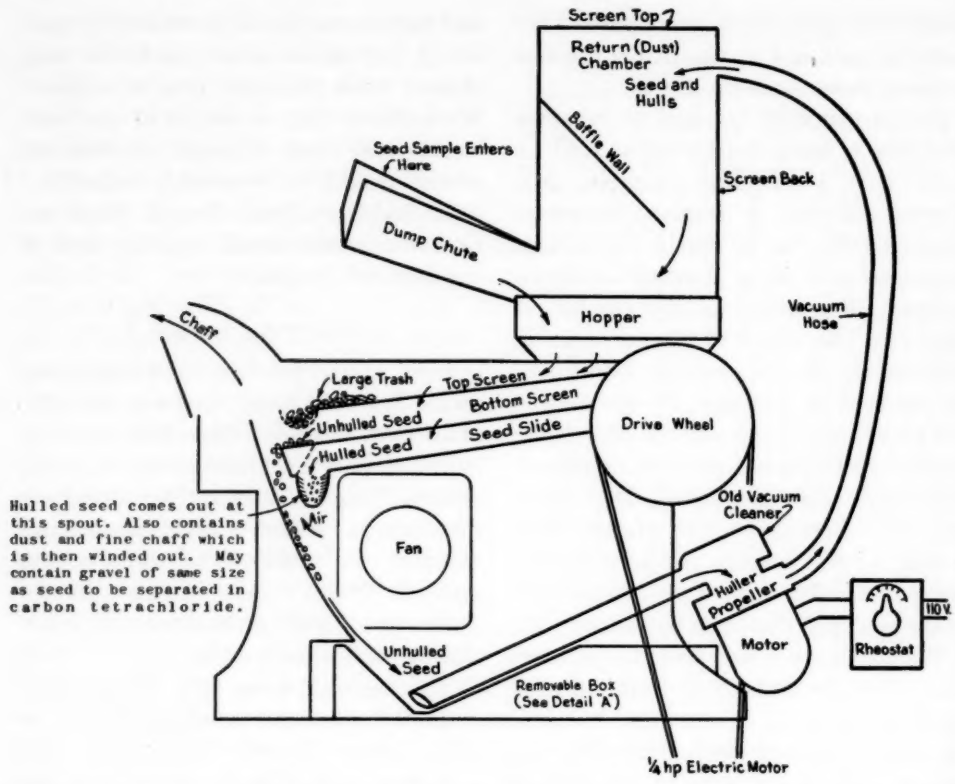
GROUND SAMPLES

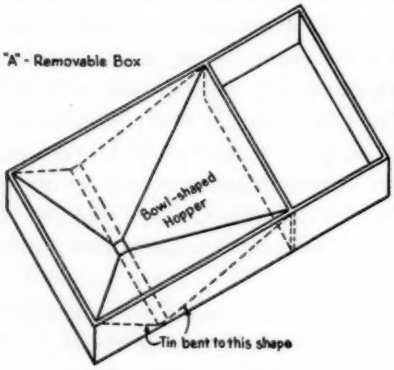
Seed traps provide data regarding yield. Before a game food can be fully evaluated, however, these data must be supplemented by information on availability. Haugen (1955) and his colleagues developed a method of collecting ground samples, in order to determine the amount of seed which remains edible to quail and other ground-feeding birds during each month of the year.

The essential tools (Fig. 3) and procedures for ground sampling are: (1) a rigid square (usually thin steel) with a sharp cutting edge to sever light stems as it is pushed into the soil; (2) a sharp pocket-knife to cut the tougher stems; (3) a flat-sided scoop, modified spatula, or wide-bladed putty knife with which to pick up all the seed, loose soil and debris; and (4) a properly labeled paper sack (or cloth sack for wet samples) to hold the collection. Each sample must be dried as quickly as possible to prevent molding.

The larger stems, leaves and rocks can be removed by passing the collection through a hardware screen with mesh somewhat larger than the seed to be studied. If it is dry, most of the loose soil in the sample can be rubbed or sifted through screen wire which has a mesh smaller than the smallest seeds to be retained. Wet soil is washed from the sample through screens before drying.

The Graetz cleaning machinery is particularly useful in handling ground



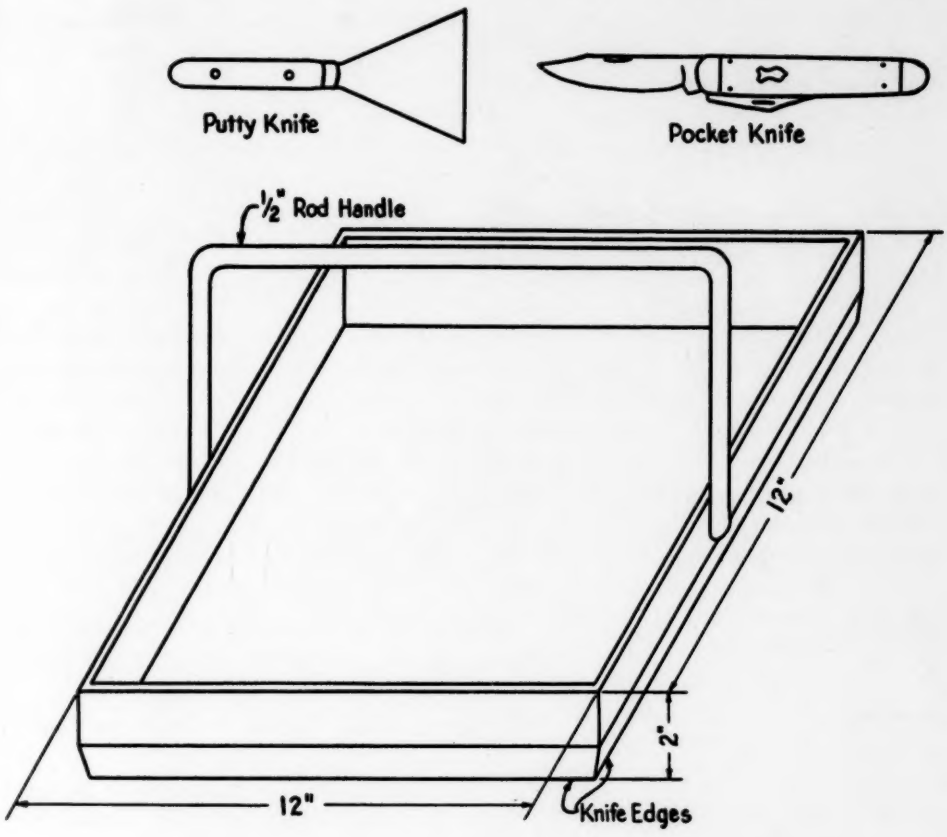


BOWL - SHAPED HOPPER

Construct a shallow box which will fit into the bottom of the cleaner and low enough to clear the seed slide. Cut a piece of tin which will fit lengthwise into the box. Then bend tin into a shallow V shape. Then cut two triangular pieces of tin to fill in the ends and slope sharply toward the center. This forms an inverted pyramid.

FIG. 2. A continuous seed huller.

samples since they contain trash that requires much time to remove by hand. Both the cleaning machine and hand screens turn out a product which includes seeds and pebbles of similar size. Dr. Haugen developed a separation technique of placing the sample in a beaker of carbon tetrachloride. The gravel will sink to the bottom of the beaker. The seeds can be skimmed from the surface of the tetrachloride, dried, and weighed. The sample is then converted to pounds per acre. The tetrachloride can be used over and over again.



STEEL GROUND SAMPLING FRAME

FIG. 3. Ground sampling equipment.

As an example of the practical usefulness of this type of study, Haugen found that at Auburn, Alabama, the seeds of bicolor lespedeza, thunbergii lespedeza and partridge peas (*Chamaecrista fasciculata*) remain available for quail the year around. More surprising was proof that bicolor lespedeza builds up a reserve food supply over a period of 2 or 3 years, because the rate of seed deterioration is low. His findings also indicate that bicolor seed is more dependable —maintains a higher poundage of available food per acre—than thunbergii lespedeza or partridge pea.

Dr. Haugen noted that to plot the highest and lowest pounds of bicolor or thunbergii seed available during the year, ground samples need be taken only in late January and September. For duck foods in southern wintering ground, W. W. Neely samples the food at flooding time (November) and again in March at the end of the season. Additional records are established just before the fall of a new crop of seed in order to measure a carry-over.

Ground-sample studies by Bissland and Roof in Florida show extremely high rates of deterioration of the seed of

duck-millet (*Echinochloa crus-galli*) and a northern strain of *Persicaria orientalis* that matured in mid-summer. These Florida records measured the extent of the disappointingly large natural loss following the false encouragement given by high yields—approximately 1500 pounds per acre of each of these promising duck foods.

In South Carolina, W. W. Neely is making a study of the game food values of various *Polygonums*. His first ground samples indicate high yields and a low rate of deterioration for certain species —and probably a build-up of unused seed from year to year. He is also studying comparative yields and rates of deterioration for other duck foods, such as wild millet, brown top millet, buckwheat, corn, cowpeas, and domestic rice. His earlier attempts to measure smartweed yields by frequent hand collection resulted in obviously incomplete measurement. Low and Bellrose (1944) noted the same difficulty in Illinois, probably accounting for the low yields of smartweeds they measured by hand harvest.

SUMMARY

Wildlife management techniques require study of the food supply—its dependability, seasonal availability and comparative ratings between species. Reference is made to five commonly used methods of evaluating game-bird foods, pointing to the need for additional methods of study.

Seed traps are described and a few examples are given to show the method of use and practical usefulness of this device.

Ground sampling is explained and several results are cited to illustrate the value of this technique.

A mechanical seed-cleaner is described as an important facility in handling either seed-trap or ground-sample materials.

These methods convert game-bird food analysis to pounds of seed per acre, thus permitting comparison between (1) species of plants, (2) various soils provinces, (3) climatic ranges, and (4) agricultural manipulations of the food element in an environment.

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OBITUARIES

RICHARD F. SHUMAN
1906 - 1954

Richard Frederick Shuman, a member of the Society, was killed in an airplane crash on Admiralty Island, Alaska, September 1, 1954. Born in Des Moines, Iowa, April 4, 1906, he attended grade and high school in Des Moines and went to the west coast in 1925 to enroll at the University of Washington in a pre-medical course. After a period out of school, he returned to the University in 1930, graduating from the School of Fisheries in 1935. During this period and until 1939 he worked with U. S. Bureau of Fisheries on the Columbia River stream surveys and with the Washington State Department of Fisheries Minter Creek Station on life history studies of silver salmon. He also worked on shellfish problems in Puget Sound.

Appointed as a fisheries biologist in the Fish and Wildlife Service in 1940, Shuman's first Alaskan assignment was Senior Biological Station Foreman at Little Port Walter where the escapement and fresh-water survival of pink salmon were under study. Despite an annual rainfall of well over 200 inches a year, the Shuman family developed a fond regard for Little Port Walter and returned for visits whenever the opportunity arose.

Assigned to red salmon investigations in the Karluk Lake system, Kodiak Island from 1943 to 1950, Dick Shuman made there his greatest contribution to fishery science. Still unpublished, this work was an attempt to evaluate the survival factors, both fresh water and oceanic, of red salmon. A sideline to the larger study brought Shuman's work to the attention of a large number of Wildlife Society members when in 1950 the Journal published his paper on bear depredations on spawning red salmon. At the time this paper evoked widespread comment, but Shuman's findings were corroborated by other biologists in the years following.

In 1950, Richard Shuman was appointed Fishery Management Supervisor for Region 6 of the Fish and Wildlife Service with headquarters in Juneau, Alaska. As scientist turned administrator, he was faced with the unusual and difficult task of aiding in rebuilding the then declining salmon fishery. He continued in this capacity until September 1, 1954 when, following the Sitka Fishery Hearing, the government airplane returning the official party to Juneau crashed with the loss of five lives. The party had engaged in stream surveys of salmon spawning enroute. This epitaph from The Pacific Fisherman is fitting: "Kelez, Shuman, and Koellen—They Died Where They Worked, on a Salmon Stream in Alaska."

Dick Shuman accomplished much in his relatively short life, but all who knew him realize that he was merely on the threshold of greater and more far-reaching accomplishments. Both the fishery and the wildlife professions have lost an objective thinker, a tireless worker, and a good friend.

In addition to the Wildlife Society, Shuman's professional affiliations included Sigma Xi and the Pacific Fishery Biologists.

An active and progressive community leader, Richard Shuman was a member of the Masonic Order, Order of the Eastern Star, Douglas Lions Club, and Douglas Volunteer Fire Department. He also found time for Boy Scout work in the Gastineau Channel area. He is survived by his wife Beryl and twin sons, Dale and Dennis, age eleven.

A partial bibliography of his writings follows:

The Recovery of Tags from Commercial Pilchard Landings in the State of Washington During 1938. Mimeo. State of Wash. April 1939. p. 1-11.

On the Effectiveness of Spermatozoa of the Pink Salmon (Oncorhynchus gorbuscha) at Varying Distances from Point of Dispersal.

Fishery Bulletin 50 p. 359-363. Dept. of Interior, Wash.

Biological Studies of the Red Salmon of the Karluk River, Alaska. Unpublished.

R. F. Shuman and Philip R. Nelson. Further Studies of Bear Depredations on Red Salmon Spawning Populations in the Karluk River System—1948. Unpublished.—W. A. ELKINS

EDWARD F. CHATELAIN

1918 - 1954

On September 8, Edward F. Chatelain was chairman of the biological session of the 1954 Alaska Science Conference. That evening, following a dinner at which he and his wife Lucile were hosts, Ed was stricken with a coronary occlusion. He passed away during the night following a short revival. Services were conducted in his home town, Ogden, Utah on September 13, 1954.

He was born in Ogden, Utah, June 23, 1918 where he spent his youth and attended grade and high school. Active in Boy Scout work, he helped charter the "Carson hikes." He entered the Utah State Agricultural College in 1936 and received his B. S. degree in Wildlife Management in 1940. Serving on the staff of the departmental publication "Juniper" he wrote under the name of "O'Malley." His summers were spent working in a canning factory, on range surveys at the Intermountain Forest and Range Experiment Station, and in R.O.T.C. training. In July of 1940 he accepted a research fellowship at the Oregon Cooperative Wildlife Research Unit, working on a study of the Columbia black-tailed deer of the coast ranges. In July 1941, he entered the United States Army and served in the states, Alaska, and the Philippine Islands commanding anti-aircraft artillery gun batteries until February 1946 when he was discharged with the rank of Captain. It was during his duty in Alaska that the challenges of big game management in Alaska aroused his enthusiasm.

Lucile Frischknecht joined him in matrimony at Pocatello, Idaho on March 15, 1943.

He returned to the Oregon Cooperative Wildlife Unit in May 1946 as research assistant and in June 1947 received his M.S. degree from Oregon State College. He was employed as an instructor in range management at Colorado A and M College from September 1947 to January 1948, as a Park Ranger at McKinley National Park February to July 1948, when he joined the United States Fish and Wildlife Service as Wildlife Management Biologist and Assistant Leader of Federal Aid work in Alaska.

"Big Ed" conducted studies on waterfowl; moose-bear relations; distribution and abundance of big game, particularly moose and caribou; and more recently, range problems of the latter two species, a study of critical consequence to these important game species. Much of the current knowledge on the caribou and moose of South-central Alaska can be directly attributed to either Ed or employees under his supervision. His contribution to the field of wildlife management will long be recognized.

Ed had the unique ability to be an excellent field, office, or laboratory worker and simultaneously maintain the best of relations with fellow workers, subordinates, and the public. He sponsored and fostered morale-building stunts such as the mock playing of sad violin music in the face of a co-worker's sorry tribulation. Always helpful, persistent, and companionable, Lucile and Ed opened their home and friendship to all.

Studious and thorough in every undertaking, his hobbies were in fields related to his vocation. He became a pilot, studied statistical methods, and assiduously read the reports relating to salmon spawning in the Cook Inlet and Copper River drainages. His leisure hours were devoted to music and sports. He was a member of

Xi Sigma Pi, Phi Kappa Phi, American Society of Range Management, and the Wildlife Society.

Ed had won a promotion the week previous to his death and was recently nominated for a Rockefeller Public Service scholarship.

The news of his death saddened all with whom he was acquainted.

Edward F. Chatelain is survived by his wife, Lucile, his mother, Mrs. Alice Chatelain of Ogden, Utah, a brother, Jack E. Chatelain of Las Cruces, New Mexico, and a sister, Mrs. Janet Rasmussen of Salt Lake City, Utah.—URBAN C. NELSON

FRANK D. HALLER

1917 - 1954

Frank D. Haller, a member of the Wildlife Society for nearly seventeen years, was stricken with a heart attack and died on September 23, 1954, at his home in Coshocton, Ohio. At the time of his death, he was taking a few days annual leave from his position in the Ohio Division of Wildlife.

Frank was born in Coshocton on May 23, 1917. He attended the Ohio State University where he majored in Wildlife Conservation and received the B. S. degree in 1940. Deciding to continue his training, he became a Research Fellow in the Ohio Wildlife Research Unit and completed the work for his M.S. degree in 1941. The thesis subject was, "An Ecological and Wildlife Study of Fencerow Communities." After leaving school, he was employed briefly as an assistant on an Ohio Pittman-Robertson ruffed grouse research project, then left for more than three years service in the Army in World War II. He served in the Southwest Pacific with a Malaria Survey Unit, attached to the Infantry. At the time of his discharge he was a Corporal in an AAF Photo Intelligence Unit. On November 18, 1945, Frank married Joyce Hartsock, then went to work almost immediately with the State of Ohio, where he had the major responsibility for developing a management plan for the Brush Creek Wildlife Area in Jefferson County. In October, 1946, Frank took a job with the Indiana Division of Fish and Game. There he served as leader of various Pittman-Robertson projects on farm game, deer, predators, etc. until May 1953. Taking advantage of an opportunity to return to his home state, he accepted the position as leader of a Pittman-Robertson rabbit investigation with the Ohio Division of Wildlife, which he held until his death.

Quiet, unassuming, even somewhat shy, Frank's abilities did not lie in the field of public relations. His first love was research, but he was developing administrative ability, which was recognized only a few days before his death by a promotion to the position of Supervisor of Research Facilities in the Ohio Division of Wildlife. He is survived by his wife and two children—FLOYD B. CHAPMAN

RECENT PUBLICATIONS

Handbook of Selected Biological References on Water Pollution Control, Sewage Treatment, Water Treatment. By W. M. Ingram. U. S. Dept. of Health, Education and Welfare, Washington. Pub. Health Biblio. Series No. 8. 1953. 66 pp. 30 cents.

Selected Bibliography of Publications on Industrial Wastes Relating to Fish and Oysters. By W. M. Ingram and P. Doudoroff. Pub. Health Biblio. Series No. 10. 1953. 28 pp. 15 cents.

Selected Bibliography of Publications Relating to Undesirable Effects Upon Aquatic Life by Algicides, Insecticides, Weedicides. By W. M. Ingram and C. M. Tarzwell. Pub. Health Biblio. Series No. 13. 1954. 28 pp. 15 cents.

Operation Wildlife Research. By Cyril Kabat and Ruth L. Hine. Wisconsin Conservation Dept., Madison, Wisc. Wildlife No. 2. 1954. 35 pp. illus. By means of cartoons and concise text, describes the scope and values of Wisconsin's wildlife research program. While the results cited refer to Wisconsin, methods and purposes apply to many states. A fine diet to force-feed the mentally starved Gilligans, Miners, etc.

Mourning Dove Populations in North Carolina. Edited by Thomas L. Quay. North Carolina Wildlife Resources Commission, Raleigh. 1954. 47 pp. illus. Includes data gathered in North Carolina as part of the Coordinated Dove Study, but presented here for the sportsmen of that state. Another fine example of sportsman-education.

REVIEWS

Conservation Law and Administration. By William F. Schulz, Jr. 1953. A Case Study of Law and Resource Use in Pennsylvania. The Ronald Press Company. New York. 607 pages. $10.00

Law and administration are often considered dull and somewhat evil, so although they are admittedly necessary, and even important, they have tended to be slighted by most trained conservationists. This is unfortunate, because a successful conservation program depends as much upon sound administration (and an enlightened public) as upon sound science. The volume under review lays bare for public scrutiny the conservation law and administration in one state, Pennsylvania. The picture does not stimulate a feeling of pride in Pennsylvania citizens. One would, in fact, suppose that those responsible for the condition of Pennsylvania's conservation law and administration would, like Adam and Eve in the garden, seek cover for their shame, but that involves several unwarranted assumptions, including the one that they have read this book. One must hasten to add that few states, if any, would escape unscathed if they were subjected to as searching a study as this.

Although the tome is fairly heavy and expensive, which may unfortunately limit its audience, it can be recommended strongly both to professionals and to the growing host of laymen who are sincerely interested in conservation, and whose influence upon conservation law and administration is frequently stronger than that of the professional conservationists. There is much in this discussion of Pennsylvania which is applicable in other areas. The author and his associates, and the Conservation Foundation, which sponsored the volume, deserve credit for having produced a very valuable contribution on a complex and usually slighted aspect of conservation.

The book includes four long chapters on wildlife matters, three on water, three on forestry, and one each on soil conservation, recreation, "legal devices", and "A Model Act for Conservation Administration." It presents throughout much stimulating background material, including policy matters, and this reviewer found the treatment generally objective and sound. (Prominent exception: ". . . game and fish continue to be available only because of artificial propagation, stocking, and rigid policing." p. 4.) Differing viewpoints are presented on controversial matters, but there is no hesitation to take a definite stand.

As stated, there is much sharp criticism of Pennsylvania conservation administration. Samples are best presented in the author's own words. He states that despite its many able men who have contributed much to the state's conservation programs ". . . Pennsylvania has failed to make the progress that could justifiably be expected. There have been and there still are obstacles to this progress to overcome." Then under the various subjects he places these obstacles into sharp focus. For example, "At all levels of government in Pennsylvania, the management of water resources is treated as though it were only slightly related to the management of grass and forest cover on the watershed, and as though it but slightly affected the management of fish and game. . .".

Lack of coordination between the conservation programs of different resources is then detailed. ". . . the seriousness of this situation is brought out by the opposition of the Agricultural Extension Service to the creation of soil conservation districts, indicating that there must be an individual or body empowered to prevent two agencies . . . from working at cross purposes." It takes six pages of fine print in tabular form to list the Pennsylvania State agencies concerned with conservation, and the lack of coordination between them is virtually the theme of the book. Even the Game Commission and the Fish Commission are two entirely separate bodies, and their law enforcement officers are such specialists that they enforce only their own respective laws.

Another weakness that is cited is the lack of attractive salaries for conservation workers. From Bureau of Census data, the author learned that the average wages of employees in the natural resource field in all states was $215, while that for Pennsylvania in this field was $154, the lowest for all major classes of employees in the state. (Liquor store—$224, Highway—$206, Schools—$193.)

The section on the Game Commission naturally interests us particularly, and in this field Pennsylvania has long had an enviable reputation. Stability of status is epitomized by the records of Dr. Joseph Kalbfus and Seth Gordon, who between them held the top staff office of Executive Secretary for 37 years. "The Commission established the first full-time training school for game protectors in

the nation . . . (its) enforcement staff is undoubtedly one of the best in the United States . . . though (it) still spends a fairly large portion of its income on game farms, . . . stocking, . . . and bounties, it is working increasingly in such constructive fields as habitat improvement, habitat protection, research, and education."

Society members, with their chief interest wildlife, will find the entire book valuable, not just the substantial sections on wildlife. In each major section there is a survey of federal statutes which is, naturally, applicable throughout the country, and these summaries of federal law will be invaluable references to conservation workers.

Although the book is over 600 pages, one does not feel that it is prolix, but rather that the book really does represent rather effective distillation of a tremendous mass of data. In parts it is quite fascinating and stimulating reading. In speaking of the state's stream pollution, one reads that "only suicides, uninformed children, and the mentally deficient voluntarily dive into the lower Monongahela River. . ." The history of the Game Commission includes an account of its exciting year of 1906, which is too fantastic even to be used by Hollywood scenario writers—fourteen of the game protectors fired upon by law violators, seven casualties, four murders, a missing body, "black hand" letters from a Mafia Society to both the governor of the state and John M. Phillips of the Game Commission, and justice finally emerging triumphant through the efforts of a famous Pinkerton Agency detective. Who said conservation administration was dull?

Certainly the best book of its kind published in America, it deserves a wide audience.—GUSTAV A. SWANSON

Sea-Birds. By James Fisher and R. M. Lockley. Houghton Mifflin, Boston. 320 pp. 1954. $6.00.

This handsome and convenient volume deals with a wildlife group that in some parts of the world is subjected to management and exploited as an economic resource. The actual subject-matter of the book is much less than what the title may justly be taken to indicate, for a subtitle restricts it to the sea-birds of the North Atlantic and the authors further explain that they are here concerned almost wholly with the tube-noses, the gannets and other oceanic totipalmate birds, the gulls and terns and their allies, and the alcids. Divers or loons, grebes, certain ducks, and two species of phalarope are listed as secondary sea-birds, but of these only the phalaropes receive any detailed discussion.

Both authors have an intense interest in sea-birds and an extensive and varied field experience with them. They have brought together in handy form in this work a great store of interesting information about the birds of the North Atlantic and have discussed it in illuminating and interesting fashion. The first chapter, devoted to consideration of the North Atlantic Ocean, is followed by others in which the evolution of North Atlantic sea-birds, sea-bird numbers and man, controls of sea-bird numbers, sea-bird movements, navigation by sea-birds, and the social and sexual behaviour of these birds are successively considered. The six principal groups of North Atlantic sea-birds and their natural history are the subjects of the concluding chapters. A list of the primary and secondary sea-birds of the North Atlantic, with their distribution; a selective bibliography that occupies more than fifteen pages; an index to vertebrate species; and an index to authorities complete the book.

Careful consideration is given to sea-bird numbers. The authors conclude that either the little auk (dovekie) or Brünnich's guillemot (murre) is the most abundant bird of the north and incline to put the little auk first. This will interest the people of Newfoundland, who are accustomed to eat "bull-birds" and "turrs", as they call these species, and who desire to continue the practice. The reviewer finds that on page 61 he is cited as authority for attributing 20,000 breeding Atlantic murres to Anticosti Island, though at the reference given he merely stated (1941) that he estimated the total number of individuals of this species in the colony at Gullcliff Bay, Anticosti, at 220. This is probably the only colony of these murres on Anticosti.

The effect of man on sea-bird numbers is examined at length. Presumably man first affected sea-bird numbers as an unrestrained predator, which he still is in some regions. In some places, however, man's intelligence was sufficient to bring about the development of planned husbandry of utilized sea-birds. This, too, continues in certain areas. More recently still, man has become, locally, regionally or nationally, a conscious or unconscious conservator of sea-bird life. As a result of the bird protection movement which has been active on

both sides of the North Atlantic for more than half a century, "we can, for the first time in human history, say that we have improved the number and variety of our wild birds for the aesthetic satisfaction that they give us and for no reason whatsoever connected with commerce or profit."

The statement, on page 12, that "perhaps still a pair or two of razorbills" breed in Maine and New Brunswick is scarcely adequate. Palmer, in "Maine Birds" (1949), does not claim the razorbill as a breeding bird in Maine, but Squires, in "The Birds of New Brunswick" (1952), records a breeding colony of 150 to 200 individuals on Yellow Murr Ledge, south of Grand Manan, N. B.

The ancient murrelet is stated, on page 29, to have been found three times in the Great Lakes area, but no farther east. The record of a specimen in the Museum of Laval University, Quebec, that was taken at Montreal in 1913 was published in 1923.

On page 85 a quotation from Roger Tory Peterson's "Birds over America" is dated 1951, but in the Bibliography the date of this work is given as 1950. This book was published in 1948.

It is stated on page 122 that the "distributional range" of Brünnich's murre and the razorbill do not overlap. Presumably the breeding range is referred to, but even so the statement cannot be maintained, for these species breed together at Bird Rocks, on islands on the coast of Newfoundland Labrador and at Witless Bay, Newfoundland.

It is surprising to find on page 209 the statement that voice comes to the young gannet or cormorant when it is "at least a week old." The reviewer has published record of the fact that the cries of young double-crested cormorants can be heard before they have completed hatching.

It is regrettable that there is no reference to the important studies of herring gulls published by R. M. Strong (Auk, 1914), R. J. Eaton (Bird-Banding, 1933 and 1934), H. H. Poor (Bird-Banding, 1943 and 1944) and R. A. Paynter, Jr. (Bird-Banding, 1947). The statement, on page 250, that juvenile herring gulls do not travel far from their breeding coasts is at variance with recorded North American conditions.

The statement, on page 278, that, although the black guillemot normally lays a set of two eggs, as a rule only one chick is reared is not in accordance with the experience of the reviewer, who, on the north shore of the Gulf of St. Lawrence, has captured a great many pairs of young black guillemots for banding.

The Bibliography apparently refers to O. L. Austin, Jr., a number of papers published by O. L. Austin, Sr.

In the first paragraph on page 26 our authors say, "Incidentally we suggest confusion between the two (shearwaters) would be reduced if *P. diomedea* were consistently called 'North Atlantic shearwater' and *P. gravis* 'Tristan great shearwater'—not just 'great shearwater.' That may or may not be so, but one cannot tell from this book, for the authors do not display the consistency that they recommend. Indeed, in the second paragraph after their recommendation they write "Northern Atlantic Shearwater"! Other variations in the text are "great shearwater" (pp. 170, 187, 189, 192, 194, 195) and "North Atlantic great shearwater" (p. 188).

We read on page 166 of young grebes being hatched (as they should be), but on the following page is a reference to young gannets being "born." Scattered through the text, indeed, are more than a dozen references to the "birth" of birds or to their "birth-place." We protest the lot of them! Birth is not an avian phenomenon. To borrow this mammalian term for reference to birds is slipshod and unnecessary, for the correct terms are readily available.

It is not strange in these times, when the editing and proof-reading of reputable publishing-houses seem to have sunk to an unprecedented low level, to find typographical and grammatical errors in the text of a new book, but it is curious to find an inserted slip listing six such errata, as though the text had been combed for them, when the simple reading of the book for review provides more than 25 additional instances of occurrence of such regrettable minor flaws. Among them is a revival of that picturesque distortion, "the .... double-breasted cormorant!"

While it is an onerous responsibility of a reviewer to call attention to matters that should be rectified, it is an unfortunate result of his doing so and supplying sufficient support for his remarks that the review may become ill balanced when the space devoted to critical discussion is unavoidably too great. In the new compendium of a very large subject with which we are here concerned the useful, attractive and commendable qualities are outstanding and should be correspondingly emphasized. This book will delight both the ornithologist and the lay observer and is the kind of volume that

one likes to have always at hand.—HARRISON F. LEWIS

A Field Guide to Animal Tracks. By Olaus J. Murie. Houghton Mifflin Company, Boston, 374 pp., illus., 1954. $3.75.

The reading of animal tracks is an art, and the interpretation of findings necessitates a great deal of knowledge of the lives of the animals who produced the tracks. Olaus Murie, with his life-time of field experience in many parts of North America, has been generously gifted with the ability of track reading and the thorough knowledge of the habits of animals which is required to produce this guide of superior quality. Most of the recent books on animal tracks (since Seton) are based on insufficient field observations, contain inadequate drawings and do not illustrate sufficiently that track images vary greatly in mud, sand, and wet and powdery snow. Murie gives careful attention to all these circumstances.

In northern Canada and Alaska, where the land is covered for half of the year with snow, accurate track information is a valuable tool in wildlife management. There especially Murie's new book will be enthusiastically received. The guide will also help in popularizing mammalogy, because tracks are so often all one sees of several species of mammals.

In my opinion there is little need for a detailed criticism of this field guide, especially since it is practically impossible to find loop holes in the statements of someone who is a foremost authority in a subject too little known to other field biologists. The guide is written in a lucid style, equally interesting to the amateur and professional naturalist. The drawings appear to be very accurate. Drawings of the structure of feet are useful to whomever is not too familiar with the anatomy of the animal described. Murie was successful in making imprints in snow appear as such, which is an accomplishment in itself. Possibly he could have used some good photographs of tracks to advantage.

One regret is that the title does not indicate that the volume is a field guide to animal signs rather than tracks. At any rate, throughout the guide Murie describes, with illustrations, the droppings, food remains and other signs of the presence of certain animals. This information, in the reviewer's opinion, makes the guide particularly attractive and useful. The book lacks desirable introductory statements about the mechanics of animal gaits, such as what gaits produce what kind of spacing between imprints.

The guide covers mammal tracks in North and Central America, and includes some tracks of birds, reptiles and insects. There is also a section on the utilization of twigs and limbs, and one on bone and horn chewing. It also provides some additional information about the life history of mammals, which makes the book interesting reading. I recommend this book as a useful addition to any field naturalist's library.—ANTOON DE VOS.

BRIEFER ARTICLES

MODIFICATIONS IN MASS GOOSE TRAPPING TECHNIQUE

Graham Cooch [1]

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During the summer of 1953, 8,400 flightless blue and lesser snow geese were trapped and banded on Southampton Island, N.W.T., Canada, by means of the techniques discussed by Cooch (Jour. Wildl. Mgt. **17**: 460–465). The possibility of heavy handling loss, especially in goslings was pointed out (*ibid*). In the summer of 1953 a satisfactory method of handling birds for several hours was devised. Once these techniques were employed, mass banding was accomplished without a single loss.

As a group of geese is being herded toward the pen, goslings exhibit a tendency to drop to the rear of the mass. When the birds have been brought to a point within a half-mile of the holding pen, the rear portion of the flock is segregated by a man running directly at the middle of the flock from one side. The adults crowd ahead, leaving a portion of the flock composed of 90 per cent goslings. The goslings

[1] Grateful acknowledgment is made to the Artic Institute and the U. S. Office of Naval Research for supplying the funds for this study.

are then led directly to the pen, while the adults are held back. Once the young birds are in the pen, the adults are brought forward and placed in the leads, which when fenced off, form a second holding pen.

In this manner the goslings are protected from trampling and plucking by adults. The goslings in the main pen are banded and released in approximately half the normal time.

Once the main pen has been cleared, additional goslings are brought in from the lead flock. This is possible because of a tendency of the goslings to segregate to one particular area in any mass of penned birds. Furthermore, they usually select the area nearest to the mass of goslings initially placed in the main holding pen. The process of bringing additional gosling flocks into the main holding pen is repeated several times, until only adults remained to be banded. The young birds once banded tended to remain in the vicinity of the pen, until an adult female is released, whereupon one or more would follow the "parent." In this manner the number of birds deprived of "parental" protection is greatly reduced.

Separate captures of 3,719, 1,722 and 1,694 birds were accomplished without the loss of a single bird. Smaller captures earlier in the season had killed as many as five per cent of the goslings involved.

The work of Peter Scott with pink-footed geese in Iceland, has paralleled our trapping. The techniques used by Scott are similar to those used on Southampton Island and were developed independently in the same period of the same year (Times, London, Aug. 26, 1953). However, the Severn group utilizes a mobile trap, which is carried to a pre-arranged spot and erected after the geese are under control. The advantage of this method is that the geese are not fatigued by long walks before being confined in a pen. Topography prohibits the use of such a technique on Southampton Island; thus birds may be driven as far as ten miles. This is especially hard on the goslings and is avoided whenever possible. Scott has been very successful in his banding attempts and in the 1953 season banded 9,000 geese with a very small handling loss.

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PLASTIC COLLARS FOR MARKING GEESE

Lewis G. Helm [1]

Missouri Conservation Commission, Columbia

The need for keeping observer disturbance at a minimum when making bird behavior studies has been pointed out by Emlen (1950). To assist the observer, color-marking of individual birds has included colored leg bands, dyes, stains, paints and lacquers, and colored body or wing markers.

In large concentrations, particularly on the wintering grounds, individual Canada geese are difficult to identify by means of colored leg bands because their legs are usually hidden when the birds are resting on water or loafing on land.

The use of colored airplane dope for marking the primary and tail feathers of ducks as developed by Sowls (1950) was tried, but the time required for application of the material proved too great for geese handled in large numbers. Furthermore, the colors were not easily seen when the geese were resting on water.

Picric acid stain, waterproof inks, synthetic enamel spray, and lacquers were tested on the plumage as possible color-marking materials; of these, only the picric acid proved promising. A saturated solution of picric acid in water was used on the undertail coverts of approximately 250 birds. This material provided a bright, yellow color, but it became dim after two or three weeks exposure to water, sunlight, and wear.

Colored skin tags of the type used on pheasants by Taber (1949) and on coots by Gullion (1951) were attached to the skin of the neck of geese with wound clips or surgical safety pins; these were quickly torn off by the marked birds or by other geese.

In an effort to use the long neck of the goose as a holder for a tag, a strip of colored plastic was sealed to a rubber band which was slipped over the neck with the tag hanging as a pendant. This type of marker was used to tag 97 wild-trapped Canada geese; however, after two birds were found with the rubber band

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and the University of Missouri cooperating.

stretched tightly across the gape, this technique was abandoned.

A neck marker was then developed by using a strip of plastic upholsterer's fabric (Koroseal) one and one-half inches wide by six inches long. This strip was placed around the bird's neck, and the two ends stapled together with a paper-stapling machine after being overlapped. Care was taken to make sure that the collar did not fit too tightly and thus interfere with neck movement or feeding. When two opposing staples were used, a strong fastening resulted, and the geese were not able to slip the collars from their necks or to break the plastic. In all cases, the marked birds became accustomed to the collar within a day or two.

At the Swan Lake National Wildlife Refuge, Sumner, Missouri where Canada geese were trapped in groups of as many as eighty with the use of the cannon-projected net trap, these plastic collars proved fast and simple enough to mark most groups in a few minutes. During the fall and winter of 1950–1951, 109 Canada geese marked with these collars made observations of local movements and feeding habits of various groups relatively easy.

Concern was felt over the possibility that these markers might upset social habits, family groupings, or mating relations. Observations of seventeen captive geese and twelve family groups of free-flying birds fitted with these collars indicated that neck markers have no long-lasting effect on behavior. Unmarked geese were wary of birds with collars for the first few hours after the collars were attached, but within the first twenty-four hours these markers caused no apparent friction among either captive geese or free-flying birds. A family group remained intact when as many as three members wore collars.

After four to six months exposure to the winter weather of central Missouri, the plastic material on captive geese became brittle, tore at the staples, and fell from the birds' necks. This period was considered adequate for observations of feeding habits and local movements during fall and winter. Recoveries of four geese fitted with these markers revealed that the collars remained on geese during long movements to the Gulf Coast of Louisiana and Texas. Two years after marking, one bird was recovered with the collar still in place. It is thought that for long-term studies, a more durable fastener could be devised with clips or wide staples. Laurence Jahn in Wisconsin has used clothing gripper snaps for this purpose with much success.

Red, yellow, and white were found to be most easily observed, and were visible with the unaided eye at ranges up to two hundred yards. Fluorescent enamels and lacquers were applied to the white plastic in various combinations of stripes and circles, and these highly visible markings were picked out at ranges up to one-fourth mile with the aid of 8 x 30 binoculars. Additional markings of contrasting colors may be incorporated by heat-bonding small strips of the plastic to the collars.

A number of trials using these collars on ducks has resulted in failures. No matter how tight the collar was placed around the ducks' necks, the birds would soon get their bills stuck in the collar in an effort to dislodge it. Varying the width of the collar did not seem to help, and it is unlikely that a plastic collar of this type is suitable for use on ducks.

For the purpose of marking large numbers of geese, the use of these neck collars was found to be quick, simple and very economical. It is hoped that this technique may provide a new tool, useful for discovering the pattern of local movements, feeding habits, and social behavior among goose flocks.

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NECK-BANDING AND OTHER COLOR-MARKING OF WATERFOWL; ITS MERITS AND SHORTCOMINGS

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Plastic collars developed and tested by Lewis G. Helm on Canada geese in the Mississippi flyway have been used experimentally by the Fish and Wildlife Service on the At-

lantic Coast since 1951. The method is recognized as having much potential value for obtaining useful information on behavior, local movement and biology of birds, though in no degree is it regarded as a substitute for the use of conventional aluminum legbands.

This innovation for recognizing particular birds has drawbacks as well as advantages. Some injuries have been reported when applied to ducks, but on wild geese the collars seem to be largely harmless. Novelty of the method and lack of public knowledge about it may cause problems in public relations, particularly in the case of conservation-minded individuals unacquainted with the purposes and nature of such marking. This obstacle, combined with potential confusion resulting from uncoordinated use of colored neck-bands by different investigators, has necessitated regulation of all color-marking of migratory birds.

All banders who wish to use a "color marking" method in their studies are urged to give careful consideration to the type of marking to be used before requesting the necessary revision of their permits; also to state definitely what the nature of the experiment will be, and why the type of marker mentioned in the request must be used to meet the requirements. In making the appraisal, consideration should be given to using the minimum amount of marking necessary, both from the standpoint of changing the bird's appearance and the amount of weight it would have to carry. It is reasonable to assume that the greater the defacement or weight inflicted upon a bird, the less chance there would be of normal behavior, both on the part of the marked individual and also in the reactions of other individuals toward it. In behavior studies, obviously, unless these reactions can be assumed to be fairly normal the results will be valueless.

The U. S. Fish and Wildlife Service in cooperation with the Canadian Wildlife Service will try to keep all types of color marking within the bounds of reason so that research requiring a certain type of marking will not be handicapped. At the same time these agencies will try to keep investigators advised of other experiments in progress which might affect their results. Approval of color-marking projects and necessary changes of banding permits will be handled by these two Services in their respective countries. In the case of migratory game birds to be marked in the United States, however, it is expected that screening of color-marking projects will take place at the flyway level and that recommendations will be supplied by the flyway representatives and regional offices before revision of a permit is requested.

Extensive tests on Canada geese on the Atlantic Coast have indicated that properly applied neck bands are not likely to be harmful in either frightening or choking this species. When a goose is first released with a neck band, some confusion may result on rejoining other birds but, as pointed out by Helm, such disturbance is brief and the marked bird is soon accepted again by its flock. Tight-fitting plastic collars could conceivably obstruct passage of food but if, as in practice, they are loose enough to allow a rod 7/8" in diameter to pass freely inside the band, danger of congestion is avoided. Neck bands used on the Atlantic Coast are 5½" to 6" long.

Further evidence that neck bands appear to cause no significant harm to geese has been supplied by the Fish and Wildlife Service's trapping and banding studies at the Pea Island National Wildlife Refuge, North Carolina. In the winter of 1952–53, half of 250 trapped Canada geese were leg-banded only and the other half were leg-banded and neck-banded. During the following trapping season, 1953–54, there were nine returns of geese that were both leg-banded and neck-banded and ten returns that were leg-banded only. Thus far, there is only one record in Atlantic Coast studies of a goose getting its lower mandible caught under a neck band.

Success in obtaining useful information by marking geese with plastic collars depends largely upon numbers and accuracy of sight records received. In particular, it appears essential that there be prearranged cooperation by qualified observers at all points where the birds are likely to appear. Adequate records cannot be obtained by casual or accidental sighting of neck-banded birds and it is not likely that such observations will provide sufficient reliable data to justify the expense of large-scale neck-banding. So far, most of the sight records on color-marked geese in the Atlantic Coast region have resulted from intensive observation by competent investigators in suitable localities.

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COLOR MARKING OF WATERFOWL[1]

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Much information is needed concerning the movement of waterfowl in Florida. In the spring of 1954, 583 ducks, mainly blue-winged teal, with a small number of lesser scaup, pintail, shoveller and black duck were trapped on the west side of Lake Okeechobee. These ducks were banded and also dyed a red color as described by Wadkins (1948) in dyeing pheasants. Birds on the water, and more easily in flight, could be identified without difficulty by the naked eye. The red ducks were readily observed from a plane when flushed from the water. The added color did not disturb normal behavior.

Technicians were alerted in the Atlantic and Mississippi flyways to report any red ducks sighted on the northward migration. The results of these reports are shown in the accompanying map and in Table 1. All except two reports were by professional wildlife workers.

This experiment was so successful that Florida will color ducks (red, green and yellow) at three different locations during this coming fall, winter and spring to help determine movements in and out of the state. Observation reports from other states will be appreciated.

TABLE 1.—REPORTED OUT-OF-STATE OBSERVATIONS OF RED-DYED DUCKS

Date	Species	Number	Location
			ALABAMA
6 April	blue-winged teal	1	6 mi. SE Auburn
			MINNESOTA
26 May	blue-winged teal	1	Mother Lake (near Minneapolis)
			NORTH DAKOTA
21 July	blue-winged teal	1	NW Sheridan County
			OHIO
18 April	lesser scaup	1	Buckeye Lake (central Ohio)
			SOUTH CAROLINA
30 April	blue-winged teal	2	Cape Romain National Wildlife Refuge
			VIRGINIA
8 April	blue-winged teal	7	Fort Eustis, James River
10 April	blue-winged teal	8–10	Fort Eustis, James River (probably same birds as observed 8 April)
			WISCONSIN
15 April	blue-winged teal	1	Mississippi River at LaCrosse
15 April	unidentified	10	Milwaukee
19 April	blue-winged teal	1	Meadow Valley Flowage, Juneau County
21 April	unidentified	5	Wheeler Flowage, Oconto County
28 April	blue-winged teal	1	Wheeler Flowage, Oconto County

[1] A contribution of Federal Aid Project W-19-R.

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A SURVEY OF BRUCELLOSIS IN WHITE-TAILED DEER IN MISSOURI

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Previous studies of brucellosis (also known as Bang's disease and contagious abortion) in big-game animals have revealed its occurrence in bison (Creech, 1930; Rush, 1932; Tunnicliff and Marsh, 1935), in elk (Allred, 1947; Lee and Turner, 1937; Murie, 1951; Rush, *op. cit.*; Tunnicliff and Marsh, *op. cit.*), in moose (Fenstermacher and Olsen, 1942; Jellison, Fishel and Cheatum, 1953), and in white-tailed deer (Bolin, Goldsby, Rheault and Eveleth, 1949). The few mule deer and pronghorn antelope tested were not infected with brucellosis (Bolin and Eveleth, 1951; Ryff, 1951). Only in bison has a high incidence of brucellosis been reported (Tunnicliff and Marsh, *op. cit.*), and only in elk has the disease been reported to have had a deleterious effect on herd productivity (Murie, *op. cit.*).

Brucellosis appears to be rare in white-tailed deer. Blood sera from 436 white-tailed deer from North Dakota were tested by Bolin, Goldsby, Rheault and Eveleth (*op. cit.*). Only one animal was found to be infected. They also report the detection of one brucellosis-infected deer among four tested by a private veterinarian in North Dakota. In a later study (Bolin and Eveleth, *op. cit.*), blood sera from 70 more whitetails were tested and found negative for brucellosis. Fenstermacher, Olsen and Pomeroy (1943) tested blood sera of six Minnesota whitetails for brucellosis and tularemia, with negative results. Recent work in Ohio (Edgington, 1951) revealed no brucellosis in the 210 deer tested there. Whitlock (1949) found no brucellosis in whitetails in Michigan.

While the results of these surveys were reassuring, the possibly serious effects brucellosis might have on deer herd productivity, and the potential danger of spreading the disease, if it was present, to domestic livestock, made it important that we ascertain whether our deer were infected with brucellosis. Recent increases in the size of both the deer and cattle herds in Missouri made the problem an immediate one.

Blood samples have been collected from white-tailed deer (*Odocoileus virginianus*) killed during the past four deer seasons (1950–1953) in Missouri. Samples were collected by Conservation Commission biologists from deer brought to deer-checking stations by hunters. Nearly all deer are eviscerated when brought to checking stations, so blood can be obtained only from the visceral cavity of freshly-eviscerated deer. No attempt was made to collect blood from deer whose visceral cavities were obviously contaminated with intestinal contents, urine or water, and in many cases no blood was available. In spite of adverse conditions, a large number of blood samples was collected each year, and, although most samples showed some degree of hemolysis, nearly all were in satisfactory condition for testing.

During the four-year study, blood samples were collected from 1,019 deer, killed in 17 counties, mainly in southern and east-central Missouri. A total of 996 samples yielded sufficient sera in adequate condition to test. These samples were collected from 352 adult males, 234 adult females, 153 fawns, and 257 deer of unknown age, about half of which were females.

All blood samples were delivered to the State and Federal Cooperative Bang's Testing Laboratory in Jefferson City, Missouri, where they were centrifuged and the sera tested for brucellosis. Deer serum was tested exactly as cow serum is, using the standard plate agglutination test, with Bureau of Animal Industry *Brucella abortus* antigen. In 1950, 1951, and 1952, all sera were tested first at a dilution of 1 to 50. Where clear-cut negative results were not obtained, sera were centrifuged a second time and tested at dilutions of 1:50, 1:100, 1:200 and 1:400. In 1953 sera were tested first at a 1:42 dilution. If further testing was indicated, sera were again centrifuged and tests were set up at dilutions of 1:50, 1:100 and 1:200.

Blood samples from 59 of the deer tested in 1950 yielded sufficient sera for further testing. These sera were tested by the Bureau of Laboratories, Missouri Division of Health, for tularemia and, again, for brucellosis, using a different strain of *Br. abortus* antigen than that used by the Bang's Testing Laboratory. Standard clinical laboratory procedures were used.

Negative results were obtained with all but one of the 996 deer sera tested for brucellosis. The one exception, from an adult lactating doe killed in 1952, reacted in an atypical manner in all dilutions from 1:50 to 1:400. The veterinary pathologist who read the tests stated that in his opinion the reaction was not charac-

teristic of that shown by sera from brucellosis-infected animals, and he considered that this deer was not infected with brucellosis.

The sera tested in the Division of Health laboratories were negative for both brucellosis and tularemia. We can assume that all of the animals tested were free from tularemia (with the possible exception of the doe mentioned above), because blood sera from animals infected with tularemia will show some reaction to *Br. abortus* antigen (Kelser and Schoening, 1948).

The high productivity of Missouri's deer herd provided circumstantial evidence that brucellosis was not present. Results of this laboratory study furnish direct evidence that white-tailed deer in Missouri are not infected with brucellosis.

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RECORDS OF THE BLACK BRANT IN THE YUKON BASIN AND THE QUESTION OF A SPRING MIGRATION ROUTE

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In the summer of 1951, three specimens of the black brant (*Branta nigricans*), constituting new locality records, were taken by me along the Yukon River between Fortymile, Y. T., and Eagle, Alaska. The first of these, a male going into its second year, was shot on July 19, approximately ten miles below Fortymile. The second, also an immature male, was shot on July 27, approximately two miles from the Alaska-Yukon boundary, on the Canadian

side. On July 28, the wings, tarsi, and feet of a brant were discovered among the fresh remains of prey lying about the aerie of a pair of peregrine falcons (*Falco peregrinus*), which were nesting on a river-bluff about one mile below the boundary on the Alaskan side. The worn condition of the primaries indicated that this too was an immature bird.

Mr. Arthur Stephen, a native Kutchin of Eagle, Alaska, and a keen observer of birds, stated that he sees some of these geese nearly every spring. Furthermore, Corporal Kirkpatrick, who operates a boat between Old Crow and Dawson, Y. T., informed John L. Buckley in 1952 that he regularly sees a few brant along the Porcupine River in the spring. Black brant were also seen in the Minto Lakes region northwest of Fairbanks in the summer of 1951. Jim D. Rearden identified one near his camp on June 23 and saw two together on June 27.

These interior records of a characteristically coastal species suggest the need for closer attention to its movements and distribution in the Yukon Basin. Although ornithological investigations have been going on in Alaska with greater or lesser intensity for about two hundred years, there is an appalling lack of information about the migratory routes of even the most conspicuous species. The Yukon Basin is an excellent case in point. A number of rather extended investigations have been conducted in this region (Dall and Bannister, 1869; Bishop, 1900; Osgood, 1909; Blackwelder, 1919; Williams, 1925) but no naturalist except Robert Kennicott has ever been on the upper Yukon or on the Porcupine and other upper tributaries during a spring passage. Yet the Yukon Valley is generally considered to be one of the most important routes by which migrating birds enter Alaska; yet there are scant data on species or numbers which occur in migration.

The idea of an important movement of black brant through interior Alaska has not received serious consideration in the recent literature on migration because this goose is considered to be so preeminently a coastal and off-shore migrant. Its habit of making long, digressive flights, seemingly in order to avoid passing over even narrow projections of land, is frequently cited as an example of its extreme aversion for overland flight. The older writers, however, not being so sophisticated in their understanding of the ecological and behavioral limitations of the brant, were prone to give credence to information about an overland contingent of migrating black brant through the Yukon Basin. This historical evidence, viewed as a whole, is emphatic.

Richardson (1851; cf. Preble, 1908) published extracts of a letter from a Mr. Murray who described a black goose, plainly referring to the brant, which regularly passed through the Yukon Valley in migration. A few birds were said also to pass down the Peel River, but they were more abundant on the Yukon.

Dall (1869:295) considered brant rare on the Yukon, where he secured but one specimen on May 29, 1868 at Nulato, but he states that brant "pass Fort Yukon in the spring, as they do at St. Michael's, being present but a few days and breeding on the shore of the Arctic Ocean." The inhabitants of Fort Yukon told Dall that brant are not seen there in the fall.

Baird, Brewer and Ridgway (1884:473) give the following account:

"Mr. Kennicott, in a note dated Fort Yukon, May 19, refers to procuring three specimens of this bird, known in that region as the 'Eskimo Goose.' He states that it arrives there the latest of all the birds, after nearly all the other Geese have passed. It flies in large flocks, and very rapidly. The three specimens were the first noted that season, and the only ones killed, although two dozen or more flocks of from 25 to 50 were seen in all; but in no comparison, in point of numbers, with the other four species. This bird is said to pass La Pierre House [(upper Porcupine)] in immense numbers in spring and fall."

Preble (1908) on the basis of the above data, suggested that there is a migration of black brant along the Porcupine River and that probably most of the birds nesting east of the Mackenzie use an overland route. He also obtained evidence of a large passage of brant down the Peel River in the latter part of May, 1904.

Finally, Bent (1925:258) summarized the migration of the black brant briefly: "Main flight is northward along the coast, but some fly overland across Alaska to the MacKenzie Valley." Here the matter has rested for nearly thirty years.

In addition to recent records which clearly show that some brant do occur on the upper Yukon, it seems to be established that brant have passed Mountain Village on the lower Yukon in the last few years. This was first brought to my attention by Dr. Barbara Blanchard Oakeson, who observed a sizeable

passage there in the spring of 1950. The spring movement that year was down the river to the turn at Mountain Village, from whence some of the birds spread out into the Yukon-Kuskokwim delta, while others traveled northward up the coast. She said the Eskimos there have long been familiar with the fact that these geese come from up the river, being the last species to arrive.

Mr. Henry C. Kyllingstad, who was a teacher at Mountain Village for a number of years, informs me that the passage of brant during his residence there was regular and of considerable size. He estimated passages of several thousand birds a day at peak periods. He also observed a similar down-river passage on the Kuskokwim at Bethel in 1946.

According to an unpublished field report by C. E. Gillham (cf. Cottam, Lynch, and Nelson, 1944), brant were common 6 miles below Kashunuk Village in the Yukon delta region in 1941, and he obtained evidence (not stated) that these birds came down the Yukon River to this area in the spring.

On the other hand, Mr. Paul Adams, Fish and Wildlife Service agent at Marshall, Alaska, believes that very few brant are now migrating down the Yukon, as he has seen only one flock of 25 birds, in May, 1952, and a few others passing by ones and twos. According to information he received from the residents of Marshall and Mountain Village, the last large passages of brant occurred in that region 15 to 20 years ago.

By far the most conclusive recent records are those of Dr. Laurence Irving for Anaktuvuk Pass in the Brooks Range. He has found black brant to be the most commonly observed geese during the spring migration there. Flocks of 100 or more individuals have been seen, and the general direction of movement is northward, clearly indicating the Yukon Basin as the route of approach to the pass. After observing migration through Anaktuvuk for six years, Dr. Irving concludes that there is a regular spring movement of black brant. This species is not seen there in the fall.

The most instructive feature of these records, covering a time span of more than 100 years, is their points of agreement. With one exception, all state that movements of brant are seen only in the spring. All agree that the brant is one of the last species to pass, usually about the middle of May; that the passage is rapid, the entire contingent passing any one point in a few days. There is also general agreement that brant are not as abundant in passage as other species of geese, except through Anaktuvuk Pass.

I believe the data presented here permit one to state beyond any reasonable doubt that there is a large and regular spring movement of black brant through the Yukon Basin. A more precise understanding of this overland migration must await the cooperative attention of a number of interested observers.

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BICOLOR AS A RABBIT FOOD

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Though the extensive plantings of *Lespedeza bicolor* made in the southeast during recent years were intended primarily for quail, there has been considerable incidental benefit to other wildlife. Bicolor is being used with various land-use types. Where changes in use patterns are contemplated the capabilities of the soil and the needs of the farmer govern the development. Many land uses are not conducive to high quail populations but they support other species. Rabbits and other mammals as well as many species of songbirds have been noted in bicolor plantings repeatedly.

Utilization by rabbits is extensive in some strips but slight in others. It is most evident in early winter on plants that have made weak growth the preceding summer. Rabbits seem to prefer bicolor strips having broomsedge growing beneath the clumps, as frequently happens in weak stands. In plantings invaded by grass, rabbits were found to sever bicolor stems in order to drop the seed heads so they could be eaten. On tall bicolor plants with large stems, the bark may be eaten to the extent that entire stems are girdled. In general, however, seeds seem to be relished more than bark.

Special observations on utilization by rabbits were made at the Oakland Club near Pineville, South Carolina. Here, after digging bicolor seedlings from a one-acre nursery in the spring of 1951, many scattered plants remained and were allowed to grow. Rabbit use of bicolor in this field was extensive in the early winter of 1953-54. By February, most stems within certain size limits had been severed, the seed heads dropped and the seeds eaten. This field may have been frequented by one or many rabbits but it is likely that the eastern cottontail (*Sylvilagus floridanus*) was the only species present.

Owing to the dispersion of plants it was possible to match tops of stems with their corresponding lower portions and so determine height of stalks cut. On February 5, fifty stems that had been severed in this manner were picked at random and measured. Height of stems before gnawing varied from 21 to 59 inches. Diameter at the cut was measured with a micrometer. The diameter of the smallest stem severed was 0.077 inch and the largest 0.285, with an average of 0.157. Probably seed had not developed on smaller stems.

Only rarely were stems partially severed. A few taller plants with large stem diameters had been barked without cutting the stems sufficiently to cause the seed heads to bend over. Perhaps rabbits have difficulty cutting off bicolor stems having diameters much more than a quarter-inch and for this reason usually do not attempt to do so.

Evidence indicated that when the falling stem toppled against adjacent vegetation and the seed head lodged too high for the animal to reach, the stem was again severed in order to make the head drop closer to the ground. Some stems had been cut as many as three times. Such multiple cutting was always in thick growth.

Height of cut from ground level varied from 10 to 22 inches, with average of 13.8. Only three stems were severed 16 inches or more above the ground. One leaning stem was cut 22 inches. These stems probably were pushed down and held between the animal's front legs while gnawed, then the lower portions sprang back to their original positions.

For assistance in collecting this information, I am indebted to E. C. Stewart, Manager, Oakland Club.

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